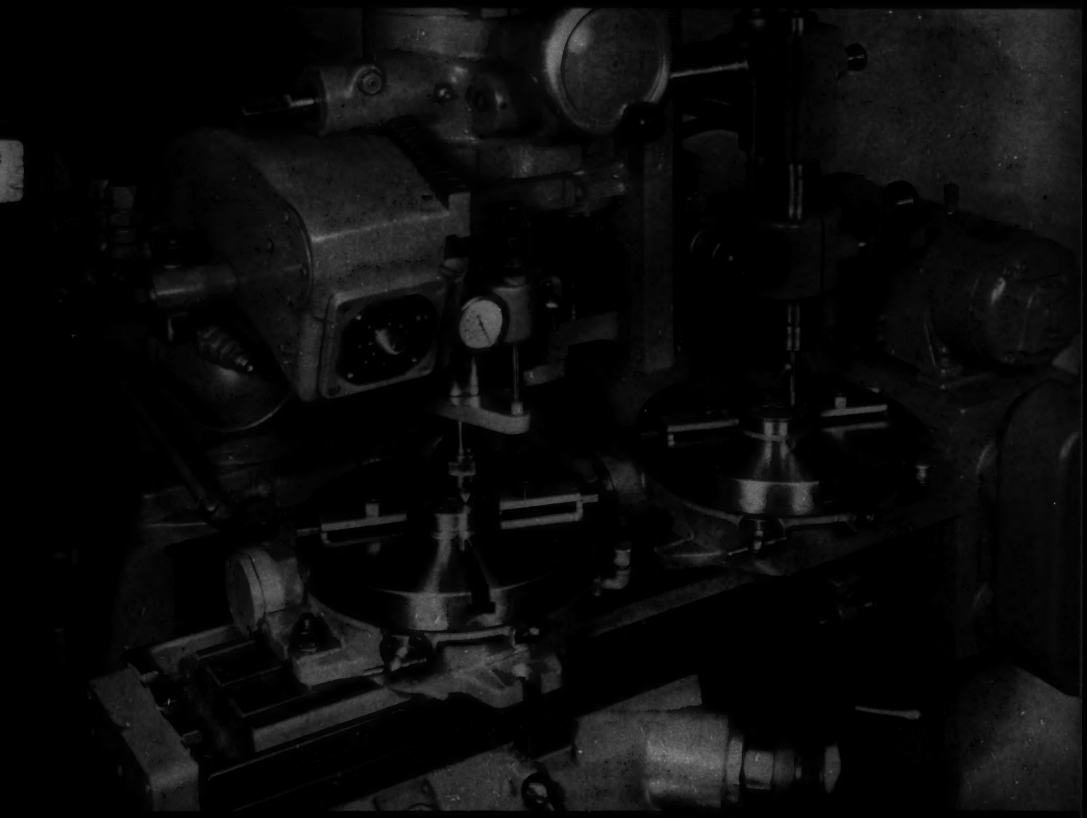
ELECTRICAL ENGINEERING

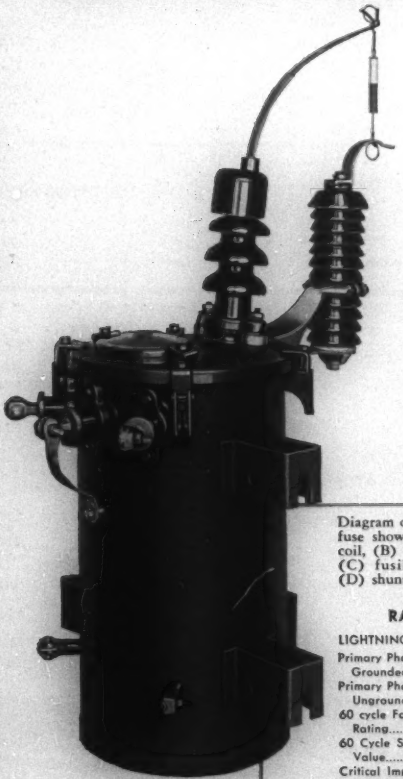
OCTOBER 1949



FALL GENERAL MEETING, CINCINNATI, OHIO, OCTOBER 17–21, 1949

LOW COST Protection

FOR YOUR *RURAL* TRANSFORMERS



Combination Lightning Arrester and Overload Limiter provides Complete, Low-Cost Protection on Allis-Chalmers Rural Distribution Transformers

COMPLETE PROTECTION for your rural transformers need not be economically out of reach — even on low revenue feeders.

Allis-Chalmers Rural Transformers with combination Lightning Arrester and Overhead Limiter offer as complete protection as you can buy . . . at a saving over many other types because of its simple, thrifty operating principle. By using this arrangement you can economically justify complete electrical protection for all transformers on your system.

SURGE-PROOF OVERLOAD LIMITER

An important feature of this protective combination is the surge-proof overload limiter. Through special two-element fuse design, fuses rated small enough for low sustained tripping values can at the same time withstand momentary load current surges equal to ordinary fuse links rated 4 to 8 times higher! This provides protection against secondary shorts and harmful overloads, eliminates costly and unnecessary storm outages — yet permits safe, efficient utilization of Allis-Chalmers rural transformer overload capabilities.

The protected transformer comes to you completely assembled as a packaged unit, ready to install.

For further details, write for Specification 2557, or call your nearby A-C sales representative.

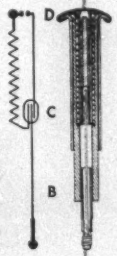


Diagram of two-element fuse shows (A) heater coil, (B) pull out wire, (C) fusible junction, (D) shunting gap.

RATINGS

LIGHTNING ARRESTER

Primary Phase to Phase Volts, Grounded 9000-13800
Primary Phase to Phase Volts, Ungrounded 6000-9000
60 cycle Fault Current Rating.....No Limit
60 Cycle Sparkover Value.....34 KV
Critical Impulse Sparkover Value (1½x40 wave) 54 KV

OVERLOAD CUTOUT

Current Rating.....50 amps
Maximum Interrupting Capacity .....1200 amps

A 2793

ALLIS-CHALMERS, 931A SO. 70 ST. MILWAUKEE, WIS.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

ELECTRICAL ENGINEERING

Registered United States Patent Office

OCTOBER
1949

The Cover: An 8-inch by 10-inch tool and die milling machine of the Cincinnati Milling Machine Company. Twin rotary tables are motor-driven through the gear box to the right of the machine table.

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VOL. 68 NO. 10

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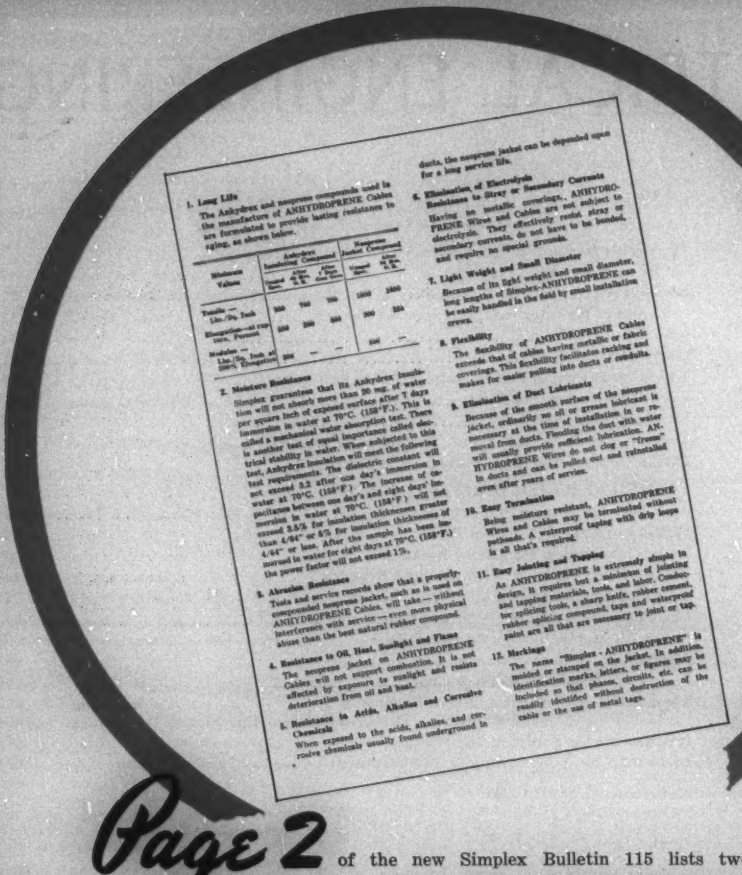

1. Long Life

The Anhydrex and neoprene compounds used in the manufacture of ANHYDROPRENE Cables are formulated to provide lasting resistance to aging, as shown below.

Minimum Values	Anhydrex Insulating Compound			Neoprene Jacket Compound	
	Original Values	After 7 Days Air Oven Test at 70°C.	After 7 Days Water Test at 70°C.	Original Values	After 7 Days Air Oven Test at 70°C.
Tensile — Lbs./Sq. Inch	900	700	700	1500	1000
Elongation—at rupture, Percent	350	300	300	300	200
Modulus — Lbs./Sq. Inch at 100% Elongation	200	—	—	600	—

2. Moisture Resistance

Simplex guarantees that its Anhydrex insulation will not absorb more than 20 mg. of water per square inch of exposed surface after 7 days immersion in water at 70°C. (158°F.). This is called a mechanical water absorption test. There is another test of equal importance called electrical stability in water. When subjected to this test, Anhydrex insulation will meet the following test requirements. The dielectric constant will not exceed 3.2 after one day's immersion in water at 70°C. (158°F.) The increase of capacitance between one day's and eight days' immersion in water at 70°C. (158°F.) will not exceed 2.5% for insulation thicknesses greater than 4/64" or 5% for insulation thicknesses of 4/64" or less. After the sample has been immersed in water for eight days at 70°C. (158°F.) the power factor will not exceed 1%.

3. Abrasion Resistance

Tests and service records show that a properly-compounded neoprene jacket, such as is used on ANHYDROPRENE Cables, will take — without interference with service — even more physical abuse than the best natural rubber compound.

4. Resistance to Oil, Heat, Sunlight and Flame

The neoprene jacket on ANHYDROPRENE Cables will not support combustion. It is not affected by exposure to sunlight and resists deterioration from oil and heat.

5. Resistance to Acids, Alkalies and Corrosive Chemicals

When exposed to the acids, alkalies, and corrosive chemicals usually found underground in ducts, the neoprene jacket can be depended upon for a long service life.

6. Elimination of Electrolysis Resistance to Stray or Secondary Currents

Having no metallic coverings, ANHYDROPRENE Wires and Cables are not subject to electrolysis. They effectively resist stray or secondary currents, do not have to be bonded, and require no special grounds.

7. Light Weight and Small Diameter

Because of its light weight and small diameter, long lengths of Simplex-ANHYDROPRENE can be easily handled in the field by small installation crews.

8. Flexibility

The flexibility of ANHYDROPRENE Cables exceeds that of cables having metallic or fabric coverings. This flexibility facilitates racking and makes for easier pulling into ducts or conduits.

9. Elimination of Duct Lubricants

Because of the smooth surface of the neoprene jacket, ordinarily no oil or grease lubricant is necessary at the time of installation in or removal from ducts. Flooding the duct with water will usually provide sufficient lubrication. ANHYDROPRENE Wires do not clog or "freeze" in ducts and can be pulled out and reinstalled even after years of service.

10. Easy Termination

Being moisture resistant, ANHYDROPRENE Wires and Cables may be terminated without pothends. A waterproof taping with drip loops is all that's required.

11. Easy Jointing and Tapping

As ANHYDROPRENE is extremely simple in design, it requires but a minimum of jointing and tapping materials, tools, and labor. Conductor splicing tools, a sharp knife, rubber cement, rubber splicing compound, tape and waterproof paint are all that are necessary to joint or tap.

12. Markings

The name "Simplex - ANHYDROPRENE" is printed or stamped on the jacket. In addition, identification marks, letters, or figures may be included so that phases, circuits, etc. can be readily identified without destruction of the cable or the use of metal tags.

Page 2 of the new Simplex Bulletin 115 lists twelve big reasons why Simplex-ANHYDROPRENE Cables can be relied upon for low-cost installation, trouble-free service and long life. They are twelve of the many advantages these cables provide through the combination of Anhydrex insulation and a neoprene jacket.

Yet even they are only a part of the valuable information this bulletin contains. You ought to know about it for it shows the way to low-cost, thoroughly-dependable transmission and distribution systems.

If you're not up-to-date on ANHYDROPRENE Cables, or are not aware that a cable consisting only of conductor, insulation, and a thin jacket can provide the electrical stability, mechanical toughness, and versatility that efficient systems demand, it will pay you to read Bulletin 115. Why not drop us a line today for your copy?

Simplex — WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 SIDNEY ST., CAMBRIDGE 39, MASS.

HIGHLIGHTS.....

Pacific General Meeting. A new record for attendance at Pacific Coast meetings was set by this year's Pacific General Meeting in San Francisco, Calif., August 23–26, with 878 members, students, and guests registered. Highlights of the meeting included a comprehensive program of technical sessions and a wide variety of inspection trips, as well as a number of interesting social events (*pages 896–900*). Included in this issue also are short authors' digests of most of the conference papers presented at the meeting (*pages 879–89*).

To Be or Not to Be? The question in this instance is whether or not the AIEE should remain a strictly scientific and educational organization and is considered by AIEE President James F. Fairman (*page 829*). The subject also has aroused a great deal of interest among the membership with opinion about evenly divided pro and con. In an effort to ascertain which course should be followed, the Board of Directors seeks the views of AIEE members and a convenient ballot is provided for that purpose (*page 890*).

AIEE Technical Subcommittees. A listing of the Institute's some 120 technical subcommittees, together with their scopes and personnel where such have been released, are included in this issue (*pages 906–19*). This is in completion of the list in the September issue (*EE, Sep '49, pp 790–804; 808–17*) which presented Institute officers and the personnel of the main AIEE committees, both general and technical, as well as the scopes of the latter.

Fall General Meeting. The 1949 Fall General Meeting of the Institute (formerly known as the Midwest General Meeting) will be held in Cincinnati, October 17–21.

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In addition to the fine technical program which has been arranged, of special interest should be the variety of inspection trips which include the Baldwin Company, manufacturers of pianos; the General Motors Fisher Body Plant; the Procter and Gamble Company; and the Oakley Colony, center of machine tool production (*pages 891–4*).

Nucleonics Conference. The second annual Conference on Electronic Instrumentation in Nucleonics and Medicine, sponsored jointly by the AIEE and the Institute of Radio Engineers, will be held in New York (*pages 895–6*).

Léon Thévenin. Almost every engineer is familiar with Thévenin's famous theorem, but few know anything of the theorem's originator. This brief article presents some of the highlights of the career of Léon Thévenin, who was born in Meaux, France, in 1857, and died in Paris in 1926 (*pages 843–4*).

High-Voltage Cable Transmission. "Ideas that today are visionary and not in the economic range, eventually may provide the necessary means for improving the utilization of high-tension cable transmission." Such ideas include the use of polyethylene or other new synthetic materials extruded over the conductor, the use of low-cost liquids such as water as the pressure medium, or perhaps the utilization of a pipe of a nonmetallic material (*pages 875–6*).

Garrison Dam Power. As far back as 1900, the Corps of Engineers was investigating schemes for utilizing the mighty Missouri River, but it was not until 1943 that a comprehensive basin plan was formulated. Features of the Garrison Dam near Bismarck, N. Dak., one of the key units of the plan, are discussed by the head of the Corps' Electrical Mechanical Design Section (*pages 847–52*).

Magnetic Recording. With increasing attention being given to those factors which limited the performance of early magnetic recording systems, magnetic recording has assumed an established position in many fields of application. This article discusses some of the techniques which contribute to high quality in such systems, and points out some of the limitations, together with suggestions as to how they may be overcome (*pages 836–41*).

Flourescent Lighting. Because of their low power consumption combined with high brightness output, flourescent lamps helped win World War II. These lamps made far more efficient use of the limited power available than the incandescent variety, thus freeing valuable energy for other duties. And even greater savings in power are indicated for the future. "Fluorescent lamps of 1949," this author states, "have reached only one-third of the maximum theoretical efficiency for the production of white light" (*pages 857–60*).

Guide for Applying Low-Voltage Air Circuit Breakers. Giving recommendations for determining short-circuit currents on d-c and a-c circuits and requirements for cascade and selective trip arrangements of circuit breakers, this AIEE Committee Report supplements the Standards on this subject (*pages 852–4*).

Semiconductor Rectifiers. Based upon four papers presented at a symposium held during the Summer General Meeting in Swampscott, this article provides a "qualitative discussion of the theories of rectification and noise generation in metal-semiconductor contacts" (*pages 865–72*).

Responsibilities of the Engineer. This significant and timely address before the Pacific General Meeting in San Francisco reminds the engineer of his social and economic responsibilities, warning him that he must take time out from his gadgets and his textbooks to assist in the fight for the preservation of human dignity and freedom against the threat of collectivism and totalitarianism that is engulfing the world today (*pages 830–3*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions*.

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Oct '48, p 43A	Pacific General Middle Eastern District
Dec '48, p 35A	Midwest General Southern District
Apr '49, p 25A	Winter General (1949)
Jul '49, p 47A	South West District Summer General

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TAILORED-TO-FIT

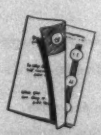
READY-TO-USE SLOT INSULATORS

specify **Inmanco**

There's no waste of time or material, no struggling to fit inaccurately cut insulating pieces—when you use Inmanco tailored-to-fit slot insulators. High-speed, specially designed equipment pre-forms Inmanco insulation accurately and economically. No further cutting or fabricating is necessary. Your assemblers quickly put the ready-to-use pieces into place . . . and your production increases, labor time decreases, and costs drop!

Inmanco Slot Insulators can be supplied to your exact specifications in any of fourteen standard styles: ordinary flat, scored flat, flat-bottom formed, or round-bottom formed—all either uncuffed, single-cuffed, or double-cuffed. Papers available include Manning 100 and 300 Rag Papers, Manning 200 and 50 Part Rag Papers, Hollingsworth and Vose Groton Tan and Red Pure Wood Pulp Papers, Acetate-Covered Papers, and other electrical insulating papers.

To start saving time and money, contact the nearest office listed below and ask for the free 8-page Inmanco Slot Insulator Bulletin. It will help you to select the right style and material for your specific requirements.



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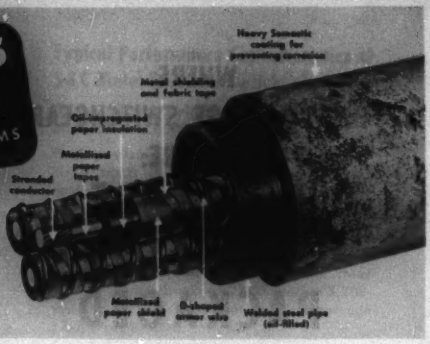
ANY WAY YOU FIGURE IT . . .

FIRST CHOICE IS OILOSTATIC

HIGH-PRESSURE PIPE-TYPE CABLE SYSTEMS



FIGURED BY CIRCUITS . . . it's 4 to 1 (for generator leads—100%)

Here are the figures by circuits installed or under contract as of September 1, 1949:

Pipe-Type System	Transmission Circuits	Generator Lead Circuits
High-Pressure Oil (Oilostatic Type)	44	25
Compression Oil	5	—
High-Pressure Gas	11	—
Compression Gas	2	—
Total	62	25

A total of 87 circuits of all types have been purchased and, of these, 80% (69 circuits), are of the Oilostatic type. For generator lead circuits alone, 100% are of the Oilostatic type. Okonite-Callender has supplied 56 of the 69 Oilostatic type circuits.

FIGURED BY UTILITIES . . . it's 3 to 1

Here are the figures by number of utilities purchasing these systems:

Pipe-Type System	No. of Utilities
High-Pressure Oil (Oilostatic Type)	21
Compression Oil	3
High-Pressure Gas	4
Compression Gas	2
Total	30

A total of 27 separate power and light companies have purchased high-pressure pipe-type systems, one having as many as 12 separate circuits in operation. Only three utilities have installed 2 types of cable systems. Oilostatic-type systems, however, have been purchased by 21 or 3 out of 4 of these 27 utilities.

OTHER OILOSTATIC FIRSTS in High-Pressure Pipe-Type Cables

- 1st transmission system, 1935
- 1st application of high-pressure 161-kv potheads, 1935
- 1st generator lead installation, 1941
- 1st cabinet-type packaged pumping unit, 1946
- 1st submarine crossing, 1947
- 1st termination directly into transformer, 1949

There are good reasons why Oilostatic* high oil-pressure pipe-type cable systems have become the predominant choice of power and light companies within so few years. Oilostatic type systems offer a combination of advantages that increase circuit reliability, save money and labor.

Higher Dielectric Strength — entirely immersed in oil under 200 lbs. pressure to insure its high dielectric characteristics; no voids in the insulation, therefore no ionization.

Greater Simplicity — space saving: no ducts, no lead sheath; no riser cable problems; relieves congestion at points where overhead lines are impractical; also saves space in generator stations.

Easy Installation — all phases installed simultaneously in pulls up to 3600 ft.; simple joints and terminals.

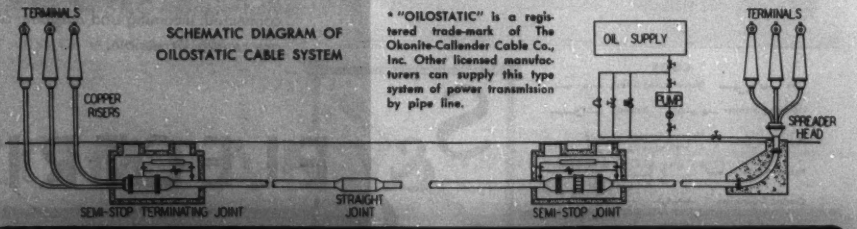
Broad Transmission Applications — highest current carrying capacity under emergency overload; no practical voltage limit; cables can be furnished for any present-day operating voltages.

Substantial Savings — when used in preference to a duct system, savings from 15 to 30% are obtained in city street installations; in open country 25 to 40% may be effected.

Same installation for land or submarine projects — unaffected by elevation, contour or nature of terrain.

Quick and easy to install, of rugged construction and requiring very little maintenance, dependable Oilostatic may be the answer to your problem when handling bulk power. For complete installation and operating details, let an Okonite engineer consult with you. Also, for your information and help is Okonite's 16 mm. colored, "Oilostatic" film, supplemented by Oilostatic File Folder EG 75. Both are available upon request. Call or write to The Okonite Company, Passaic, New Jersey.

SCHEMATIC DIAGRAM OF OILOSTATIC CABLE SYSTEM



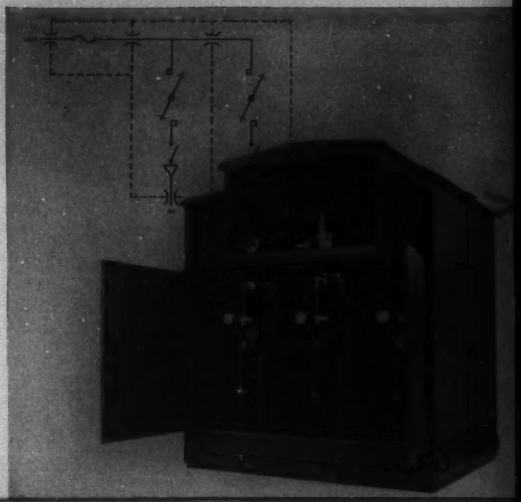
* "OILOSTATIC" is a registered trade-mark of The Okonite-Callender Cable Co., Inc. Other licensed manufacturers can supply this type system of power transmission by pipe line.

OKONITE-CALLENDER paper insulated power cables

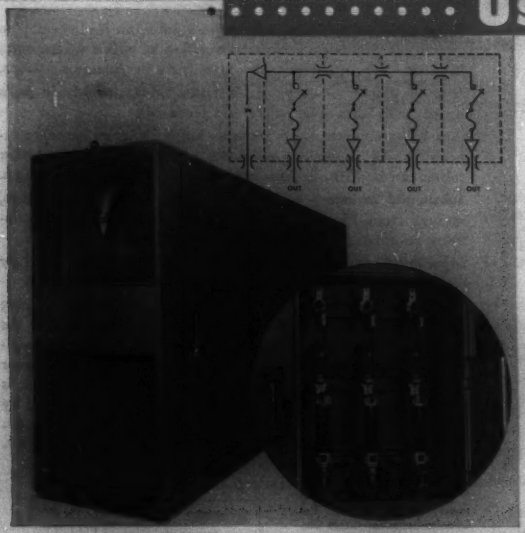
7741

WHERE HIGH VOLTAGE SWITCHGEAR MUST BE:

RELIABLE
ENCLOSED
PACKAGED
AND YET
LOW IN COST



USE S & C METAL-



Utilizing Alduti Interrupters and SM Power Fuses, S & C Metal-Enclosed Switchgear Units offer these important advantages:

- ***Large Savings in Equipment Costs*** as compared with circuit breakers, for Primary Switchgear, Secondary Switchgear, and Load Center Switchgear installations.

- ***Ease and Economy of Installation*** because all equipment within each unit—including meters, arresters, potheads, metering transformers, etc.—is factory assembled and connected. Incoming and outgoing connections are readily accessible.

CODE

Fuse — Disconnecting Switch

Lightning Arrester — Pothead

Meter — Through Bushing or wall opening

Potential Transformer

Current Transformer

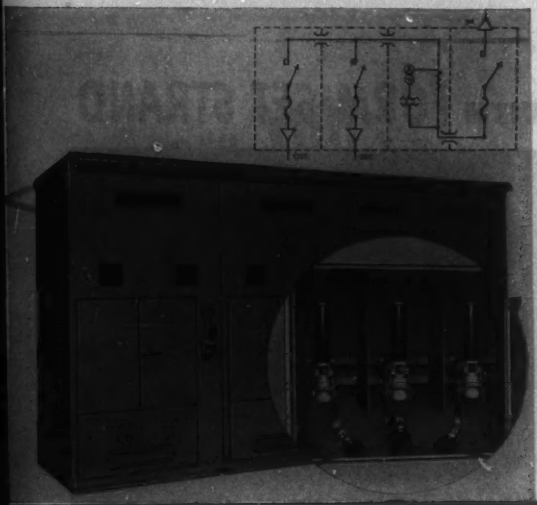
S & C Alduti Interrupter Switch

Above 15,000 volts

15,000 volts and below

S&C ELECTRIC

Formerly SCHWEITZER & CONRAD, INC.



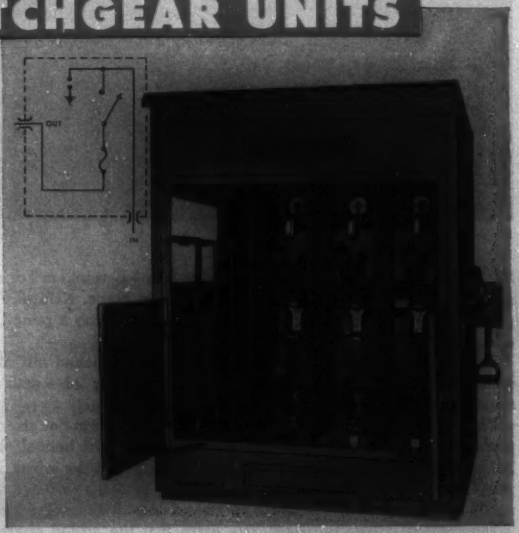
Typical Performance Characteristics of S&C Metal-Enclosed Switchgear Units:

- ***Load Current Switching*** . . . up to 600 amperes on 2,300- to 33,000-volt circuits.
- ***Magnetizing Current Switching*** . . . of transformer banks whose load currents are within the continuous current ratings of the switches, that is, to 1200 amperes on 2,300- to 13,800-volt circuits and 600 amperes above 13,800- to 33,000-volt circuits.
- ***Charging Current Switching*** . . . of three phase capacitor banks of 2,000 kvar on 2,300-volt circuits; and 3,000 kvar on 4,160- through 13,800-volt circuits.
- ***Short Circuit Protection*** . . . to 40,000 amperes, rms asymmetrical, on 2,300- and 4,160-volt circuits; 30,000 amperes on 13,800-volt circuits; and 20,000 amperes on 33,000-volt circuits. Or, stated in symmetrical 3-phase kva: 104,000; 180,000; 448,000; and 715,000 respectively. For higher short circuit interrupting ability, consult the factory.

ENCLOSED SWITCHGEAR UNITS

- ***Minimum Maintenance Expense*** since a blown fuse is fully restored by simple field replacement of its refill unit. Also, in the average application, the switches require just ordinary switch maintenance.

Shown here are typical units from regular production. Any special design can be made to meet your specific requirements. To get this modern, reliable, money-saving switchgear for your next installation — consult the telephone directory for the S&C representative in your city, or write us direct.



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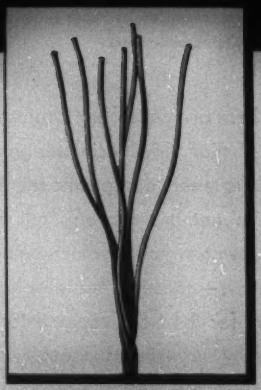

Notice that the strand in the large illustration—Bethlehem Form-Set—has no seizing, yet every wire lies calmly in place. Naturally it is going to slip easily into the fitting—as easily as sliding a pencil into a length of pipe.

But look at that other strand. The wires have bushed out at the ends like a porcupine's quills. Obviously, a seizing job—with consequent loss of time—is required here.

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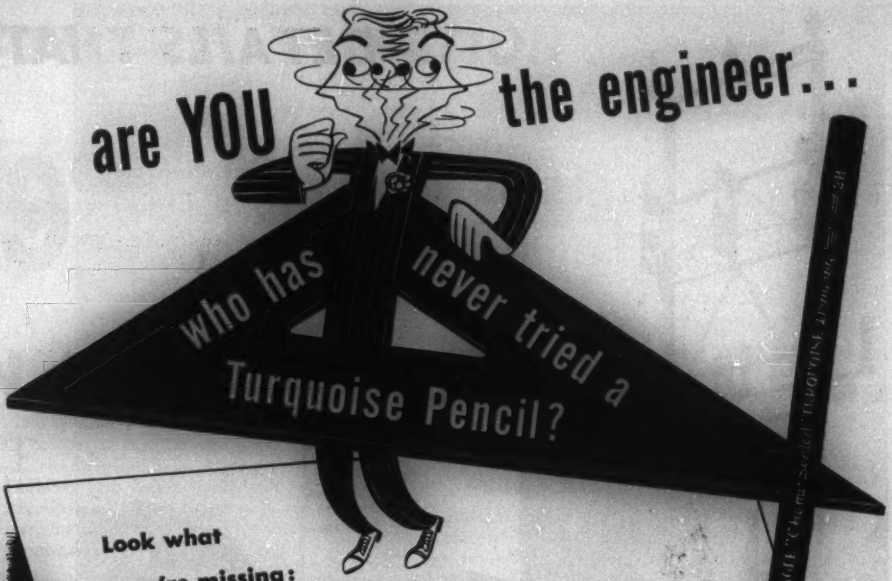

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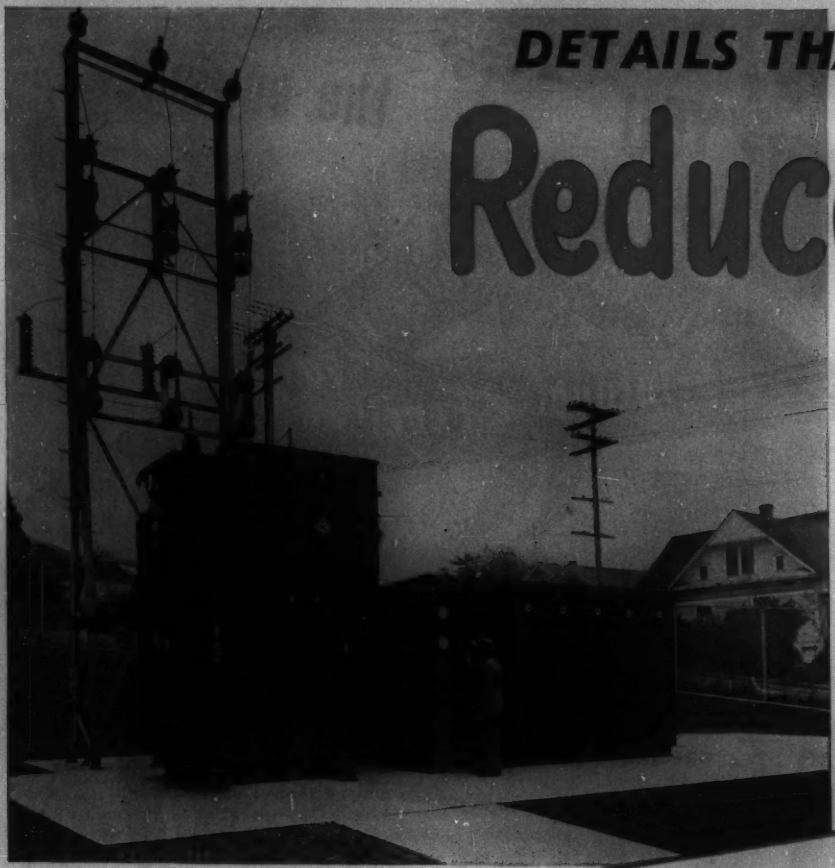
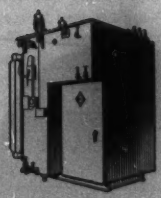


DETAILS THAT Reduce



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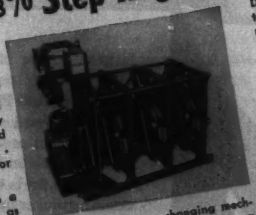

It holds fluctuations to a narrow band . . . low as ± 1%! Variations are averaged by a voltage integrator which controls the tap changing mechanism. Feather touch control panel is conveniently located in a weatherproof cabinet on front of transformer at shoulder level.

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To Be or Not to Be?

JAMES F. FAIRMAN
PRESIDENT AIEE

Whether AIEE should confine its interests and activities to those of a strictly technical and educational nature is a problem receiving considerable thought by Institute members. President Fairman here outlines the problem.

TO BE OR NOT TO BE—a strictly scientific and educational organization is the question on which the Board of Directors is seeking the opinions of the members of the Institute. It is a question which the Board has been pondering for some time. It is a troublesome question. It is brought into increasingly sharper focus by social, economic, and political trends which concern more and more of our members. It deserves an answer.

The resolution introduced by Director Smith at the Board meeting in April was the first step toward finding an answer. The appointment by the Board of a special committee to clarify the problem and to stimulate discussion among the members was the second step. (See *EE, June '49, p 536.*)

In the August issue (*EE, Aug '49, p 700*) under the subtitle "Institute Policy" is an account of the discussion at the Section Delegates Conference at Swampscott, Mass. This was the third step. The special committee has considered the matter in the light of the discussion presented and the questions raised at that conference as well as in correspondence, and has prepared a further statement which appears in this issue (*page 890*).

The next step is up to the Sections. They are asked to consider the problem at an early meeting and to report their opinions promptly to the special committee in order that the latter may summarize them for presentation to the Board at the Winter General Meeting.

In the hope that I can be of service to the Institute and to the Sections in this connection, I am making this problem the subject of my talks at the Section meetings which I shall attend during the next few months. I am not presuming to tell the members what the answer should be. I am trying to present the problem in its various aspects and to obtain their answers. AIEE Vice-Presidents and Directors are also available for the same purpose and will welcome invitations from Sections to discuss the problem.

As I see it, there are three courses open to us. One is that proposed by the Smith resolution, another is that which would be proposed by an equally positive resolution to the contrary, and a third is the present undefined course somewhere between the first two which gives rise to the problem. It appears that we are not particularly effective in our present course and want to try some other way. May I suggest what would seem to be the logical consequences of our choice of one of the other two courses.

If we adopt the Smith resolution or its substantial equivalent, we shall confine our work as an organization to the field of electrical engineering technology. The Institute will assume the place contemplated for it in plans *B* or *D*. No changes in organization will be involved. There will be no requirement for increased income to cover new services and activities. The Institute will continue to be what it has primarily been since its founding. Our members who are interested in the nontechnological problems of the engineering profession will have to turn to other organizations such as those contemplated in plans *B* or *D*, for the handling of those problems.

If we adopt an affirmative resolution contrary to the Smith resolution, we shall expand our services and activities to include the nontechnological problems of the engineering profession. The Institute will assume the place contemplated for it in plan *C*. We shall have to augment our staff and committee structure, either separately or jointly with other like-minded societies or both, to carry on this new work. Additional income will be required as the work expands. The Institute will become a somewhat different type of organization. Our members who are interested in the nontechnological problems of the engineering profession will not have to turn to other organizations for the handling of those problems.

It should be borne in mind that the choice we are making now is without prejudice to the final answer to the problem of over-all organization of the engineering profession, it is only for the purpose of guiding our activities in the interim. It will enable the Board of Directors to decide more promptly as the cases arise whether or not to engage in or to participate in nontechnological activities which may be proposed by our members, committees, Sections, sister societies, or other agencies.

Actually we have been steering a course more nearly in line with the Smith resolution than otherwise but there are more and more occasions when pressure is brought to bear on the Board to depart from that course. Such deviations as have been made have not had uniformly happy results and the question always arises as to the Board's right to commit the Institute to carry on or take part in some activity outside its clearly recognized field. If the Institute is to embark on a course contrary to the Smith resolution, it should be prepared to do so on a basis which will assure results as creditable to the Institute as are the results of its technical activities.

Which course shall we choose? Let us have the courage to make a choice and the determination to see it through.

Outline of the talk given by AIEE President Fairman to various AIEE Sections in the West.

James F. Fairman, is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y.

The Social and Economic Responsibilities of the Engineer

W. C. MULLENDORE

WHILE I was thinking about what I should say upon this rather ponderous subject, I happened to open a book which I had read some years ago—a book written by the man whom I believe to be the greatest philosopher of this century. I refer to Jose Ortega y Gasset, the author of "Revolt of the Masses"; and the book to which I refer is "Toward a Philosophy of History," written by him in 1940. I was, in fact, rather startled to find that I had opened this book just by chance at the exact page whereon Ortega had summarized just what I wanted to say, and I at once decided that I should begin by quoting both as a text and as an introduction from pages 103 and 104 of Ortega's "Toward a Philosophy of History." Ortega says: "My book 'The Revolt of the Masses' was written under the haunting impression—in 1928, be it noted, at the climax of prosperity—that this magnificent and miraculous technology of ours was endangered and might crumble between our fingers and vanish faster than anybody imagined. Today I am more than ever frightened. I wish it would dawn upon engineers that, in order to be an engineer, it is not enough to be an engineer. While they are minding their own business, history may be pulling away the ground from under their feet.

There is a tendency for the specialist such as the engineer to become so absorbed in his responsibilities toward his work that he is apt to neglect his higher responsibility, as a citizen, toward society as a whole. In this article the author warns us of the crisis that is facing civilization today, and charges the "men of trained mind" with the duty of arousing the unaware.

"Alertness is what we require. We are not allowed to confine ourselves within our own professions, but must live in full view of the entire scene of life, which is always total. The supreme art of living is a consummation gained by no single calling and no single science; it is the yield of all occupations and all sciences, and many things besides. . . . Human life and everything in it is a constant and absolute risk. The deadly blow may come from where it is least expected. A whole culture may run dry through an imperceptible leak. . . . This much is clear: The social, economic, and political conditions under which he (the engineer) works are changing rapidly.

". . . People believe modern technology more firmly established in history than all previous technologies because of its scientific foundations. But this alleged security is illusory. . . .

"Indeed, it is just this feeling of security which is endangering Western civilization. The belief in progress, the conviction that on this level of history a major setback can no longer happen and the world will mechanically go the full length of prosperity, has loosened the rivets of human caution and flung open the gates for a new invasion of barbarism."

I am an alarmist—an unashamed and unapologetic alarmist. Ortega said he was frightened in 1928 and more so in 1940. I began to be alarmed by the threat of Socialism in the United States some 18 years ago and my alarm has increased year by year as collectivist policies have grown into the Welfare State. My deep concern has been aggravated by an apparent lack of awareness, if not indifference, on the part of political, business, and other leadership in the face of what has seemed to me to be a growing disintegration of the foundations of our achievement and progress. It has seemed that too often, the specialist—the scientist, the engineer, the business manager, the politician, the labor leader, the doctor, the educator—in this period of upheaval, of confusion, disorder, and bewilderment, has wanted to avoid looking at and trying to understand what was occurring in the broader fields of human life on this planet. While joining in a chorus of reassuring platitudes as to the inevitability of progress, too many of these leaders have immersed themselves more and more in their specialty. Others have frankly avoided the unpleasant facts, arguing that there was nothing they could do about the situation anyway, so why be disturbed? The result has been to leave the field of public discussion to the domination of the demagogues who achieve the power which they seek in the confusion which they create, and to the optimist who allays the discomfort caused by the disagreeable aspects in the future outlook by emphasizing only the more favorable and promising.

Man in the 20th century has become so intrigued by and so dependent upon technology that he seems to have forgotten that discoveries and inventions in the fields of science, mechanical and electric energy in their manifold applications—all these wonderful gadgets and devices thus made available—are after all not an end in themselves but merely tools to be used by man in the improvement and development of his life on this earth. Further, these wonderful discoveries have not repealed a single one of the

Full text of an address presented at the AIEE Pacific General Meeting, San Francisco, Calif., August 23–26, 1949.

W. C. Mullendore is President, Southern California Edison Company, Los Angeles, Calif.

Ten Commandments nor a single one of the basic laws of human nature or the laws governing and controlling the development of the spiritual life of the human being.

True, the vast stores of energy which are now at his command to supplement his own energy have freed man from much drudgery and multiplied manyfold his power to produce goods and services; but the development of the individual man still is dependent upon his freedom to develop his own innate ability, and that development remains roughly proportionate to the effort exerted by the individual in drawing out and refining those latent and innate abilities. Order and organization are more than ever necessary in a specialized and industrial society, and the preservation of individual freedom remains proportionate to the self-reliance and the maintenance of the dignity and self-respect of the individual.

Let me get away from those abstractions and generalities and say what I am trying to say bluntly and more plainly. It is this: A nation, a society, or a civilization, can and will crack up and disintegrate despite the finest technology, and productive machinery of the highest potentiality, if such society, nation, or civilization defies, ignores, and violates the laws of God governing human conduct on this earth. The latest developments in science, possession of the highest of technical skills will not protect us against the destructive powers of human greed, envy, and hatred aroused, mobilized, and directed by demagogic leaders who, for the sake of power, "loosen the rivets of human caution and fling open the gates for a new invasion of barbarism." Some of our new neighbors and dependents among the nations of the world can offer eloquent testimony to the truth of these statements.

W. C. Mullendore

For the sake of emphasis (since this is our main theme) let me repeat the thought in different words. It matters not how brilliant or accomplished our scientists and engineers are; it matters not how much we know about chemistry, physics, and atomic fission; how many labor-saving devices and intriguing gadgets for intercommunication we could make available; nor does it matter how productive we could be if we obeyed the laws of God instead of the dictates of the Devil. If the human beings, for the service of whom all these wonderful things are intended, insist on fighting and cheating, and robbing their fellow man of his earnings, and in general following false leaders who appeal to their greed and to their baser emotions as a means of gaining power over them, then our culture and our civilization will be destroyed. And all of this supports the conclusion that it is even more important to preserve and to improve human relations and the structure of human society than it is to make further progress in atomic research or television or to discover some new law of thermodynamics. All of these advancements in knowledge are of no avail if the human beings in whose behalf the knowledge is sought insist on reverting to barbarism and destroying the possibilities of living peacefully together.

But our subject is economic and social responsibility of the engineer. Why single out the engineer? Has he any special or particular responsibility in this moment of history? I believe that a good case can be made out for the proposition that he has such a special responsibility. Why? First, because the engineer has contributed much to the heavy reliance upon technology and the practical applications of scientific advance as the solution to all our problems, social and economic. Second, the engineer and his associates in the field of technology have made available to mankind in general and to the demagogues in particular means of transportation and communication which have brought the whole of mankind into closer proximity, and have made it possible for the demagogue and rabble-rouser, the marauder and the wrecker, to reach those mass populations to the growth of which still other scientific and engineering achievements have contributed. But whether the engineer has a special responsibility over and beyond his fellows who are leaders in other fields is relatively unimportant and we need not stop to argue the point here. Certainly it will be admitted that our responsibility to mankind in general and to our own family, community, and nation, in a time of peril such as war or other devastating calamity, is commensurate with our ability. In time of war, when there is general and widespread recognition of the threat to our freedom and even to our survival, we do not have to be told and we do not question that our first duty is to do all that we can to help defend our country, and unless the pursuance of our special pursuits is held to be the best way we can make our contribution to the common effort, that pursuit will be held secondary or abandoned until the war is over.

Well, here we are in the year 1949, in the beginning of the fifth year after *V-J* Day, in a very sick world. Our civilization and our culture are challenged and under attack both from without and within by a destructive power now holding sway over a large part of Europe and Asia. This malevolent power has its infiltrating agents and

saboteurs and their fellow-travelers and dupes at work day and night in every other country of the world, including our own. In our struggle to defend ourselves and our culture and institutions against the open and hidden threats of that power, we have assumed immeasurable burdens not only for maintaining our own national defense, but the economic and rehabilitation burdens of impoverished foreign nations having a total population at least twice that of our own.

Already in fighting wars against enemies whom we believed menaced our civilization, we have sacrificed hundreds of thousands of lives and incurred obligations against our future earnings equal to the savings which we have accumulated throughout our history as an independent nation. Nor is that by any means all. Before, during, and since our involvement in World War II, the same destructive foreign ideologies of collectivism and totalitarianism which enslaved Russia, destroyed Europe, and have now engulfed Great Britain, have been flowing in upon us and making distinct headway in destroying and supplanting those distinctive American institutions of freedom which were and are the source and secret of our strength. Over the past 16 years in particular, we have been increasingly abandoning the new, modern, liberal American system of limited Federal, republican government, and substituting therefor the reactionary old-world plan of a centralized paternalistic government with its creeping paralysis of individual initiative and self-reliance which are the indispensable components of freedom.

The "processes of democracy" have been used to induce large and diverse groups of our people to surrender to the central government, that is, to the Congress and to the President and his bureaucracy, those powers reserved to them by the Constitution of the United States, in exchange for subsidies, special favors, or handouts taken from the people and redistributed at high cost to them by and through an ever-growing Federal bureaucracy.

The minority groups receiving handouts now form a majority and those supplying most of the wealth are the exploited minority. That is to say, through these many devices for collection and redistribution of wealth, agents and agencies of the Federal Government have as their clients or dependents the majority of the voting population of the United States. Thus self-reliance and initiative of our people have been undermined. No people ever have or ever will preserve their individual liberty once they have lost their self-reliance and become dependent upon Government for their economic planning, direction, and welfare.

This is the day and the age of the demagogue. Throughout history the demagogue has been a menace. He is the arsonist, the saboteur, the dynamiter, in the field of human relations. Unrestrained by a proper regard for the basic moral laws and principles which hold society together and make progress possible by restraining the destructive passions of men, the demagogue deliberately and recklessly arouses and inflames the emotions of human beings in order to create a wave on which he may ride into the position of power which he seeks.

With the explosive advance in the technique of communication and transportation in the 20th century, the demagogue was quick to recognize the unique opportunity afforded him thus to reach and to arouse great masses of people. In the world generally, the demagogue brought on war and revolutions. In the United States of America, he took advantage of the waves of emotion and the fundamental disturbances created by war and violence, and he capitalized particularly upon the economic conditions resulting from worldwide wars and revolutions. Gradually at first, but finally with great speed, power was surrendered by the people in the United States as elsewhere throughout the world, to a central government under the persuasion of clever demagogues, and through the manipulation of skilled but perverted assistants drawn from the so-called intellectual world.

You ask: Well, just what does this have to do with the subject, "The Social and Economic Responsibility of the Engineer?" What are we to do about all this disintegration of our culture? The answer which I would give has already been indicated. We are in the midst of a crisis. We are perilously near to the "point of no return." Obviously, the great majority of our people are quite unaware of their peril, and for that reason one duty above all others rests upon each of us who sees and knows of the near approach of disaster. That duty is to do our utmost to awaken our fellow-citizens, to arouse them from their lethargy, from their indulgence in the very practices and support of the very policies which are destroying them. It is as if we were again living on the frontier and as scouts had discovered the approach of a band of Indians intent upon massacring our neighbors. In this situation, men of trained minds must become scouts charged with the duty of arousing and alarming the unaware. As Ortega said: "Alertness is what we require. We are not allowed" in this time of peril "to confine ourselves within our own professions."

"But," someone says, "just what is it that you propose we should do? After all, we are engineers. We have work to do which is essential both to the maintenance and progress of great industries. Our work necessarily requires specialization and concentration and we are here at this meeting to consider together some of the problems bearing directly upon the responsibilities with which we are charged. What would you have us do? Drop every thing and devote ourselves to the political, economic, and social worries you are so excited about? And supposing we did, what could we do except to add to the confusion?"

Well, by way of summary and in conclusion, let me try to answer those perfectly proper questions. First of all, I am not proposing that we should all take a leave of absence from our jobs and take to the hustings for the purpose of sounding the alarm about the imminent danger to our basic institutions. Of course, we have important work to do and we must keep at it. I am saying, however, that regardless of our devotion to the means by which we earn our livelihood, we also have a paramount responsibility to ourselves and our children to preserve the foundations and the framework of this house within which we live. Along with our responsibility for our daily work, we have an even higher or primary responsibility of doing what we reasonably can to ward off and defeat the forces

which are now forging chains of governmental power and authority which will restrict and regiment the lives of our children to the point of enslavement.

In the face of such fundamental issues affecting the whole future of our civilization as those which confront us today, silence and inactivity on our part indicates indifference, and the indifferent or complacent are dangerous allies of our enemies, whether or not they know it or mean to be such. Those who help to conceal danger, or distract attention from danger, help to lull the people generally into a false sense of security. Those who go further and give positive assurance that all is well so far as our free institutions and our individual freedom are concerned, do still more harm. And most destructive of all, of course, are those who lend their aid and support to the programs which are a part of the great Socialistic advance of the day.

No, I do not apologize for bringing this most important aspect of your social and political and economic responsibility before you on this occasion. Neither am I concerned lest some may feel that this smacks of partisan politics. On that score, unfortunately, I could not be partisan because both great political parties in the United States today, like those in England, are largely committed to the continuance of the Socialist program. But I am concerned lest it be said of us by our children that when their heritage was being destroyed, their fathers, notwithstanding their education and opportunity to know the facts, were so busy with their electrons and formulas, with their great engineering projects and the perfection of television and other gadgets, that they had no time to help in the preservation of the fundamental liberties without which the whole of that heritage will be lost.

I respectfully submit that in this hour of peril, whether in your office, in your home, your church, or at a business convention, one of the subjects that must be given primary consideration, must be brought out in the open and discussed so that our real concern about it may be manifest, is this subject which I have endeavored to discuss with you today.

I close with a quotation from John Stuart Mill which sums up the message I would like to leave with you:

"A people may prefer free government; but if from indolence, or carelessness, or cowardice, or want of public spirit, they are unequal to the exertions necessary for preserving it; if they will not fight for it when it is directly attacked; if they can be deluded by the artifices used to cheat them out of it; if by momentary discouragement or temporary panic, or a fit of enthusiasm for an individual, they can be induced to lay their liberties at the feet of even a great man, or trust him with powers which enable him to subvert their institutions—in all these cases they are more or less unfit for liberty; and though it may be good for them to have had it even for a short time, they are unlikely long to enjoy it."

Electron "Lenses" Used to Measure Magnetic Fields

As the result of a series of electron-microscope experiments at the National Bureau of Standards, Dr. L. L. Marton of the Bureau's electron physics laboratory has developed an electron-optical shadow technique which provides a valuable tool for the quantitative study of electrostatic and magnetic fields of extremely small dimensions. The new method makes use of an electron lens system to produce a shadow image of a fine wire mesh placed in the path of the electron beam. From the distortion in the shadow network caused by deflection of the electrons as they pass through the field under study, accurate values of field strength are computed. (For further details, see two articles by L. M. Marton and S. H. Lachenbruch, "Electron-Optical Observation of Magnetic Fields," *NBS Journal of Research*, October 1949, and "Electron-Optical Mapping of Electromagnetic Fields," *Journal of Applied Physics*, November 1949.)

The new development, which is based on extensive theoretical analysis, should provide a powerful means for broadening present knowledge concerning space-charge fields, fields produced by contact potentials, patch fields in thermionic emission, charge distribution in a gaseous plasma, wave-guide problems, and basic magnetic properties of metals.

The principle of the shadow method was discovered in the course of a study of a recording wire magnetized in evenly spaced short pulses by means of a conventional magnetic recording head. In practice, the recording wire—or other object to be studied—is placed between an electron source and a system of electron lenses. The lens system focuses the electron beam to form an image of the wire on a fluorescent screen. By placing a wire mesh of known gauge just beyond the back focus of the lens system, a shadow image of the mesh is superposed on the image of the wire. The portions of the shadow network adjacent on the screen to magnetized regions of the recording wire are then found to show considerable distortion.

Formulas have been derived by S. H. Lachenbruch of the Bureau staff which permit the calculation of consistent absolute values of field strength in magnetic or electric fields of various geometrics from experimental measurements of the position of the wire mesh, the displacement and magnification of its shadow image, and the known constants of the apparatus.

Perhaps the greatest value of the electron-optical shadow method lies in its utility for exploring complex electric and magnetic fields in which a probe of size greater than the electron would disturb the field under study. The shadow technique now provides data for accurate calculation of the absolute value of the intensity in the neighborhood of a specimen of any size or shape without altering the field.

Arcs Between Moving Electrodes

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A NEW technique has been developed for studying characteristics of high-current arcs. The method consists of moving one electrode in the form of a steel tape at a high speed relative to the other electrode in the form of a rod. A d-c arc is drawn between the two electrodes.

With the moving tape as anode and the rod as cathode, a stable arc can be maintained without difficulty. This arc does not leave a continuous track on the anode, but instead travels ahead by a series of jumps. At each spot where the arc strikes, an anode spot is formed. For a given speed and current, the anode spots are of uniform size and spacing. Each anode spot comprises a melted area, circular or elliptical in shape. At the center of each spot the molten metal has been drawn up by some type of force action into a peak which projects above the surface of the tape. There is clear evidence of the intense heat concentration in the spots. Once an anode spot is formed, the arc tends to anchor at that spot and to extend in length as the tape moves ahead. The arc continues to lengthen until a new spot is formed by a discharge from the arc plasma to the surface of the tape underneath the cathode. This tendency to anchor is a characteristic of the anode spot, which is in contrast to the continuous rapid motion shown by cathode spots on a metal surface. The current density in the anode spots is high and may reach thousands of amperes per square centimeter.

High-speed motion picture studies of the phenomena show that the arc is not disrupted as the tape moves ahead and that a new anode spot forms before the arc leaves the old one. A study of the high-speed motion pictures shows that each anode spot consists of a jet of ionized vapor and metal particles. These jets are projected outward at right angles to the surface of the anode and exert a force on the cathode.

With high currents at low speeds, the heat input to an anode spot is so great that the spot apparently grows in area faster than the tape moves ahead. The anode spots then merge or overlap forming what appears to be a continuous melted track on the tape as shown in Figure 1. There is, however, no reason to believe that the original anode spot ceases to exist under these conditions.

The formation of anode spots and their characteristics has been studied in atmospheres of air, argon, and helium, and the same tendency to anchor was found for all three atmospheres. The spots, however, were of larger size in the inert gas atmospheres than in air. The phenomena have been studied with tapes of steel, copper, and aluminum, and rod electrodes of carbon, steel, tungsten, copper, aluminum, and brass.

Figure 1. Anode track (magnified) on steel tape

Cathode — 1/4-inch thick carbon rod; tape speed—36 feet per minute; current—160 amperes; electrode separation—1/8 inch

With the moving tape as cathode, stable arcs were formed in argon and helium atmospheres. The cathode spot does not have the same tendency to anchor as the anode spot. Rather, it is in erratic rapid motion. The track left on the tape is a continuous one. The surface of the tape which has been traveled by a cathode spot has a clean appearance, as though the oxide film had been removed. (See Figure 2.)

The tendency of the anode spots to anchor is believed to be of significance in particular in connection with switching and circuit-breaking devices. It appears that once the high current density column has formed an anode spot, the resistance to lateral movement is very strong. This is somewhat in contrast to the performance of the cathode spot where a continuous movement of the spot seems to take place. Thus, the energy input to the cathode spot is spread over a larger area. It is believed that this difference in behavior probably is related to the difference in the particles impinging on the two surfaces, the anode being bombarded by an electron stream and the cathode by positive ions.

Figure 2. Cathode track (magnified) on steel tape

Anode—1/4-inch thick carbon rod; tape speed—18 feet per minute; current—86 amperes; electrode separation—1/16 inch

This method of studying the characteristics of the high-speed moving arc yields valuable data concerning the nature and the characteristics of high-current arc phenomena. These characteristics cannot be observed by the usual experimental methods, because, at slow speed, melting of the tape does not leave a record that can be deciphered.

Digest of paper 49-129, "Characteristics of Arcs Between Moving Electrodes," recommended by the AIEE Electrical Welding Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Not scheduled for publication in AIEE *Transactions*.

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Heating of Cables in a Duct Bank

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IN THE calculation of the temperatures attained by underground cable systems installed in duct banks, it has been customary to base such calculations upon a set of experimentally determined thermal resistances commonly known as the "National Electric Light Association Duct Heating Constants," by which the temperature rise above the ambient earth temperature of cables located in the duct bank may be calculated under stated conditions of duct occupancy.

While this procedure generally has been satisfactory, there has been an increasing need for a fundamental method by which the temperature rise at the surface of the cables could be calculated in terms of the heat loss of the cable-in-duct system, its geometry, and the thermal resistivity of the earth. This would permit the clarification of certain ambiguities now attendant in the duct-constant method, and a direct comparison of the relative thermal efficiencies of the pipe-type and cable-in-duct transmission systems.

Considering the simplest of cable-in-duct installations consisting of a single cable in a single duct, the cable surface is an isothermal, but strictly speaking neither the duct wall nor the duct periphery are isothermals due to the fact that the cable is not centered in the duct and because all points in the rectangular duct periphery are not equidistant from the cylindrical source of heat flow. In the case of a multicable-in-duct structure, the situation is further complicated by the usual dissymmetry of the cable positions and the interaction of the heat flow from the various cables.

A theoretical solution of this problem which is sufficiently simplified to be practical must involve the assumptions that the duct walls and duct periphery may be treated as cylindrical isothermal surfaces, and cable engineers are generally agreed on this point. (The main points of diverging opinion concern the determination of the thermal resistance between cable and duct wall, and the formulation of the equivalent radius of an isothermal cylinder representative of a group of loaded ducts which properly accounts for the interacting heat flows from these ducts.) On this basis, the temperature rise of the sheath of a given cable in a duct bank above ambient earth temperature may be expressed by the equation

$$\Delta T_c = 0.00411 \frac{Q_c \beta}{D_s} + 0.012 Q_d' \rho' \log_{10} \frac{2L}{R_d} \text{ degrees centigrade} \qquad (1)$$

in which Q_c is the watts loss per foot of the given cable, Q_d' is the total watts loss per foot in the duct bank multiplied by the loss factor, β and D_s are the surface resistivity factor and diameter of the cable sheath, L is the depth to the center of the duct bank, and R_d is the equivalent radius of the loaded ducts. The first term of the equation represents the temperature drop between cable sheath and duct wall, while the second term represents the temperature drop in the bank and surrounding earth, in which ρ' represents the effective thermal resistivity in degrees centigrade centimeters per watt of this part of the thermal circuit. This second term readily is modified to include differing thermal resistivities for the duct structure, earth, and pavement if the duct lies under a street, but normally this refinement is unnecessary.

There appears to be a general feeling among cable engineers that because of the complicated heat flow pattern which exists in the immediate vicinity of the ducts of a multicable-in-duct installation, the value of R_d cannot be derived on a reasonably simple theoretical basis. As a result, there is a tendency to accept the so-called "equal periphery" method as a simple and satisfactory means of evaluating R_d. In this method, R_d is taken as being the radius of a circle whose perimeter is equal to the periphery of a boundary line drawn around, and tangent to, the inner walls of the loaded ducts.

It must be realized, however, that R_d is merely a means to an end which is the calculation of the temperature rise of a particular duct wall (assumed to be isothermal) which is operating in the vicinity of other loaded ducts. Looked at from this point of view, the value of temperature rise may be determined by graphically plotting the lines of heat flow or much more simply by the application of the principle of superposition.

By application of the principle of superposition to the heat fields produced by each loaded duct, it may be shown that R_d is equal to the geometric mean radius of the loaded ducts, that is, the nth root of the product of the radius of a duct and the $n-1$ distances from one loaded duct to each of the other loaded ducts.

The applicable value of β in the first term depends upon a number of factors including the material of the duct wall. An analysis of available theory and test data indicates that β may be taken as equal to 800 degrees centigrade square centimeters per watt for terra cotta ducts, 1,000 for transite (Korduct) ducts, and 1,200 for fibre ducts, surrounded in each case by a concrete envelope.

The over-all accuracy of equation 1 is dependent primarily upon the accuracy with which ρ' can be determined for the particular duct location; this value may vary over wide limits from place to place. Using what appears to be an average value for ρ' of 75 degrees centigrade centimeters per watt, the equation is still more accurate than the use of the conventional duct-heating constants, because it takes into account the actual geometry which may differ from the geometry inh erent in these constants.

Digest of paper 49-134, "The Temperature Rise of Cables in a Duct Bank," recommended by the AIEE Insulated Conductors Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Techniques for Improved Magnetic Recording

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IN RECENT YEARS, considerable attention has been given to those factors which are known to have limited the performance of early magnetic recording systems. As a result of this, magnetic recording has advanced to a position of leadership in the recording of sound. Furthermore, magnetic recording has been used and is being proposed for many applications other than the conventional recording of speech and music. There are many instruments using magnetic recording as an essential element, either under development or actually in use by government agencies and other groups.

It is the purpose of this article to discuss some of the old and new techniques which contribute to high quality in magnetic recording systems, and to show some data representing the performance characteristics which now may be obtained under the most favorable operating conditions. Some of the present limitations of magnetic recording will be pointed out, and suggestions will be given as to possible methods of approach in overcoming those same limitations.

This article describes some of the techniques which may be used to improve the frequency response, reduce the distortion, and increase the signal-to-noise ratio of magnetic recording systems. Also discussed are some new methods of measurements by which these improvements may be evaluated. The author believes the application of the techniques to practical systems will not necessarily follow immediately; however, magnetic recording is already well established in many fields of application and its future looks bright.

All of the data and curves presented are based on measurements taken with plastic-backed magnetic-coated recording media. Unless otherwise specified, the recording system considered is the system using a demagnetized medium and ultrasonic bias.

FREQUENCY RESPONSE

General Considerations. Early in the revival of interest in magnetic recording systems during the past decade, intense activity was directed toward the improvement of the frequency response of magnetic recording systems for relatively short recorded wave lengths. As a result of this activity, it is now possible to obtain a much better frequency characteristic on magnetic tape at a speed of only 7.5 inches per second than was possible when carbon-steel wire was used as the recording medium at a recording speed of 60 inches per second. It is not quite fair to compare the performances of such widely different recording media. However, if the performances of the best wire available today are compared with the carbon-steel wire of five years ago, it still is found that there has been a tremendous improvement.

Curve *A* in Figure 1, for example, is an audio-frequency response curve which was taken on a sample of domestic coated tape about one year ago. Since that time, other samples from the same source have given slightly improved frequency-response characteristics. For these newer samples, the relative response at ten kilocycles is four decibels higher.

Effect of Intensity of Bias Field on Frequency Response. The effect of using an ultrasonic bias field to reduce nonlinear distortion in magnetic recording systems has been discussed elsewhere.[1,2] In a more limited way, the effect on the frequency response of a magnetic recording system of varying the intensity of the bias field also has been described in the literature.[2,3] To make an intelligent selection of optimum bias current requires fairly complete data on both frequency and distortion characteristics as a function of bias current. It is seldom possible to find a value of bias field which will give both minimum distortion and best relative high-frequency response. There is no simple rule by which the optimum bias current can be determined, because various samples of recording media do not exhibit identical or even typical characteristics of distortion versus bias current. Consequently, any bias current setting necessarily must be at a compromise value. This value should be chosen with as complete knowledge as possible as to the effect which that choice will have on all of the performance characteristics of the recording system.

A family of frequency-response curves is shown in Figure 1. Both the bias and audio currents were held constant for each curve. To get the family of curves, the bias current was varied over a wide range. There is little change in response for the bias currents corresponding to curves *A*, *B*, and *C*, but as the bias current is increased successively by a factor of two for curves *D* and *E*, both the output at the frequency of maximum response and the relative outputs at higher frequencies are diminished. Practically all of the output which was lost due to the increase in the bias current can be regained by increasing the audio recording current in direct proportion to the increase in bias current. This is shown by the curves of Figure 2 in which, for the two upper curves, the ratio of audio current to bias current

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was held constant for all values of bias current. For the lowest curve, the audio current was held constant, resulting in a decreasing ratio of audio to bias currents with increase in bias current. The relative response was not improved at high bias currents by the increase in audio current.

Effect of Recording Heads on Frequency Response. In the past, much more importance has been attached to the development of a good reproducing head than of a good recording head. However, poor high-frequency response may result from a poor recording head just as readily as from a poor reproducing head. The primary requisite for a recording head which is good from the viewpoint of high-frequency response is that the decay of the audio field, as a function of distance from the trailing pole face, be as steep as possible.

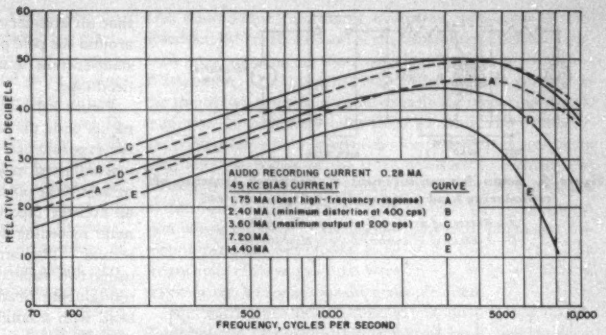
RELATIVE OUTPUT, DECIBELS
FREQUENCY, CYCLES PER SECOND
AUDIO RECORDING CURRENT 0.28 MA
45 KC BIAS CURRENT
CURVE
1.75 MA (best high-frequency response) A
2.40 MA (minimum distortion at 400 cps) B
3.60 MA (maximum output at 200 cps) C
7.20 MA D
14.40 MA E

Figure 1. Audio-frequency response curves for domestic coated tape

During the passage of a magnetized element of recording medium through the decaying audio field beginning at the trailing pole face, it also should be subjected to several cycles of a decaying ultrasonic field. Ideally, this action should stabilize the remanence on the element at a value which is directly proportional to the instantaneous value of audio field which existed when the element was in the gap of the recording head. If the element is subjected to a sufficient number of cycles of decaying bias field, there should be no remanence due to the bias field alone. This also is a desirable condition, as will be shown subsequently.

For tape recording, the alignment of the gaps in the recording and reproducing heads is of utmost importance in obtaining the best possible high-frequency response. The two gaps must be oriented so that the corresponding elements of the reproducing head are in the same position relative to the record as were the elements of the recording head during recording. Usually, this simply means that the two gaps should be straight and parallel. At a recording speed of 7.5 inches per second, the wave length of a 7,500-cycle-per-second signal is one mil. If the gaps are out of alignment by this amount from one side to the other, the response at this frequency will be zero. If one gap is curved and the other straight, the conditions are worse because there is no alignment possible which would prevent certain cancellation effects at the high-frequency end of the audio range.

In some instances, the presence of loose magnetic material at the trailing edge of the gap produces an effect similar to that of misalignment.

One prominent manufacturer of magnetic recording tape is preparing standard test recordings on one-quarter-inch tape for alignment purposes. These certainly should serve a useful purpose, especially for recording work of a professional nature.

Effect of Reproducing Heads on Frequency Response. The effect of the gap length of the reproducing head has been thoroughly discussed in previous papers.[1,2] In general, for good high-frequency response, the effective gap length should be as short as practicable. In practice, the gap length must be a compromise, because the available output voltage at all frequencies is considerably reduced for a physical spacing between pole faces of less than about one-quarter mil. Frequency-response curves were made for a certain system, using identical operating conditions except that for one reproducing head the air-gap spacer was one-quarter mil while for another it was one-tenth mil. The response for the second head was lower at all frequencies than that for the one-quarter mil head (curve *A*, *B*, or *C* of Figure 1), being six decibels down at 50 cycles per second and 13 decibels at 10 kc. It should be pointed out that the foregoing conclusion concerning the lower limit for gap length applies only to this specific case. The smallest practical gap depends upon such factors as the relative reluctances of the various parts of the magnetic heads and upon the magnetic properties of the medium itself. It may be possible that the development work on new media and new head designs now in progress will permit the use of

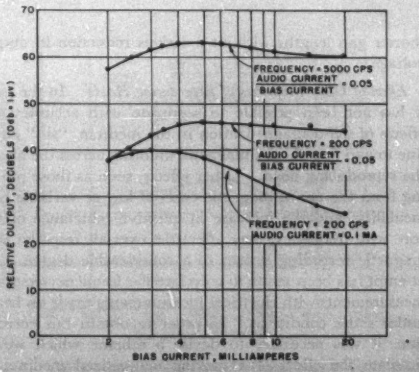

Figure 2. Audio output versus bias current

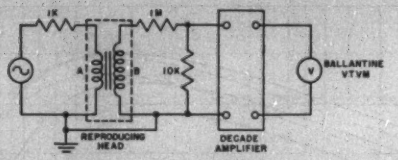

Figure 3. Setup for measurement of frequency response of reproducing head using auxiliary magnetizing coil

A—10 turns of number 34 wire, auxiliary coil
B—2,000 turns of number 46 wire, playback coil

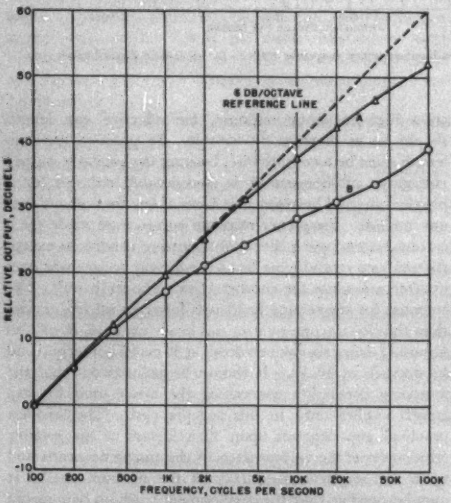

Figure 4. Frequency response of reproducing heads as "transformers;" head A has a laminated core and head B is a solid metallic magnetic head of the same dimensions as head A

shorter gap lengths without a serious reduction in output voltage.

Effect of Other Properties of Reproducing Heads. In the past, it has not been possible to segregate with accuracy the effects of self-demagnetization in the medium, "slit" effect due to gap length, and magnetic shunting across the gap of the reproducing head. Other effects, such as those resulting from the use of magnetic cores of low or variable permeability, and the increase in effective reluctance of the core with frequency, may affect the over-all response of a magnetic recording system to a considerable degree. An attempt has been made to correlate the frequency-response measurements with electrical measurements made on heads under static conditions. In order to obtain this correlation, it was necessary to devise a scheme which would simulate the effect of a moving magnetized medium as closely as possible. Under certain conditions, it was found that an auxiliary magnetizing coil of a few turns, wound around the pole pieces at the gap and energized from a constant-current source, would simulate the moving magnetized tape.

Figure 3 shows the setup which was used for the measurements with the auxiliary magnetizing coil. In obtaining the experimental data, the current in the magnetizing coil was adjusted to such a value that the voltage at the terminals of the playback coil was equal to that obtained when an average tape was used with the same head in a magnetic recording system at a frequency of 100 cycles per second. The curves in Figure 4 show the data obtained using two radically different magnetic structures for the reproducing head. Head *A* is an excellent reproducing head with a laminated core structure. Head *B* is a solid metallic magnetic head of the same dimensions as *A*. The 6-decibel per octave line for an ideal head is shown for comparison. If there is good correlation between the frequency-response measurements under actual recording conditions and these measurements, it can be seen that head *A* should be about nine decibels better at ten kilocycles than head *B*, exclusive of gap-length, gap-shunting, and self-demagnetization effects.

Frequency-response curves for an average tape were made using each of the two reproducing heads mentioned previously. For these curves, the speed of the tape was increased to four feet per second, in order that gap-length, gap-shunting, and self-demagnetization effects would be negligible. The data from the previously described test using the auxiliary magnetizing coil at the gap of the reproducing head were compared with these frequency-response curves. The correlation appeared to be so satisfactory that it is hoped that further experiments of this kind may lead to the development of improved reproducing heads, especially for those applications requiring good response at frequencies well above 10 or 20 kc.

DISTORTION

At present, there is to our knowledge no standard method of measuring or specifying the distortion of a magnetic recording system. The greatest difficulty in setting up such a standard seems to be in finding a measure which gives good correlation to subjective listening tests. The following methods have been used or suggested for distortion tests:

1. Measurement of all significant distortion components by means of a wave analyzer, using a single frequency for recording.
2. Measurement of third-harmonic distortion only.
3. Measurement of total distortion, using a distortion meter.
4. Measurement of intermodulation by means of commercial test equipment.
5. Double-tone distortion measurement using two nearly equal frequencies and a wave analyzer.

The first objective in the measurement of distortion in a magnetic recording system is the determination of the optimum operating conditions for that system. It is usually not practical to operate at the bias current for minimum third-harmonic distortion at low frequencies. It then becomes necessary to determine the effect, on frequency response and distortion, of operating at a bias other than

that required for minimum distortion. The curves in Figure 5 illustrate this point. Curve *A* represents the third-harmonic distortion as a function of bias current, the audio input being readjusted for each experimental point to give an output six decibels less than the saturated output. Curves *B* and *C* are similar curves for outputs 12 and 18 decibels below the saturated output, respectively. The readings taken were based on a system with equalization to give a flat playback frequency response. The readings for fifth-harmonic distortion were taken at the same time. These are not shown because they follow nearly the same curves as the third-harmonic values. The magnitudes of the fifth-harmonic distortion components are about one-tenth the values for the corresponding third-harmonic components. They may be considered insignificant therefore as compared with the third-harmonic components for the system upon which the measurements were made.

The measurement of total distortion by means of a distortion meter cannot be recommended because such a measurement does not yield useful information for analysis. In principle, some form of intermodulation test equipment seems desirable for measuring the distortion in a magnetic recording system. In practice, however, commercial test equipment of this kind has not been satisfactory. The major difficulty experienced in the use of such equipment has been due to modulation noise. Under certain conditions it has been found that the same value of intermodulation was indicated by the test equipment regardless of whether or not the high-frequency oscillator in the input circuit was energized. The conclusion is that modulation noise, rather than intermodulation products, was the major factor in determining the indication. In a sense, modulation noise can be considered as one form of distortion. However, it does seem desirable to separate and actually measure each component of distortion rather than to group two or more components together with the noise.

These faults can be partially overcome by use of a wave analyzer for separating the various distortion components from each other and from the modulation noise. This method is more tedious and is subject to two difficulties. First, the frequency response of an unequalized magnetic recording system is not flat. This makes it difficult to interpret a reading of an intermodulation product unless it is corrected on the basis of an assumed equalization which does not add appreciably to the distortion. In the second place, certain existing distortion products may be overlooked, since they may be masked by modulation noise, or even by one of the reproduced test signals. If the pass band of the wave analyzer is too narrow, the presence of small amounts of flutter may make it impossible to obtain a satisfactory reading. If it is too wide, the effect of modulation noise is more pronounced, and greater care must be exercised in selecting the test frequencies in order to separate the distortion products.

After reviewing these methods of making distortion measurements, and after some preliminary experimental work, it is concluded that a double-tone measurement of distortion would be the most satisfactory, especially in the higher audio range where ordinary third- and fifth-harmonic measurements are difficult and sometimes impossible.

The double-tone method of distortion measurement was described by W. H. Erikson of the Stromberg-Carlson Company at a meeting of the Acoustical Society of America, Washington, D. C., April 1948. The method consists of the use of two sinusoidal equal-amplitude recording signals separated in frequency by a fixed amount, the difference depending upon the region of the frequency spectrum being used and the ability of the wave analyzer to separate the distortion products. For instance, equal-amplitude signals of eight and nine kilocycles might be used, giving a separation of one kilocycle. In this case, the most important distortion products were found to be of the third order. The frequencies of these products were $2f_1-f_2$, or $2f_2-f_1$, that is, seven or ten kilocycles for the example cited.

The third-order double-tone distortion depends on the medium, the bias amplitude, the signal level, and the wave length of the recorded signal. Figure 6 shows the double-tone distortion for two different output levels. Figure 7 shows the effect of varying the bias field. Figure 8 shows the double-tone distortion as a function of frequency for two different recording speeds. This indicates that the distortion is a function of the recorded wave length on the

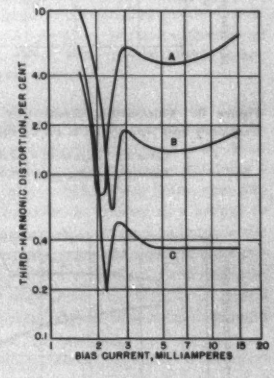

Figure 5. Third-harmonic distortion versus bias current at 6, 12, and 18 decibels below saturated output

Curves A, B, and C are for output voltages of 7.5, 3.75, and 1.9 millivolts, respectively

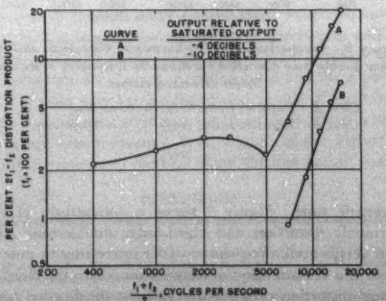

Figure 6. Third-order double-tone distortion versus audio frequency at four and ten decibels below saturated output

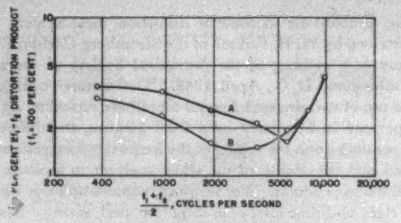

Figure 7. Third-order double-tone distortion versus audio frequency and bias current at six decibels below saturated output

Curve A: Bias current = 2.5 milliamperes; output = 4.3 at 400 and 10,000 cycles per second

Curve B: Bias current = 4.0 milliamperes; output = 4.3 millivolts at 400 cycles per second and 1.8 millivolts at 10,000 cycles per second

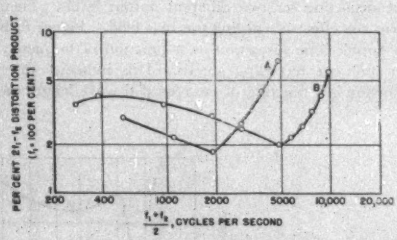

Figure 8. Third-order double-tone distortion versus audio frequency and tape speed at six decibels below saturated output

Curve A: Tape speed = 3.8 inches per second
Curve B: Tape speed = 7.5 inches per second

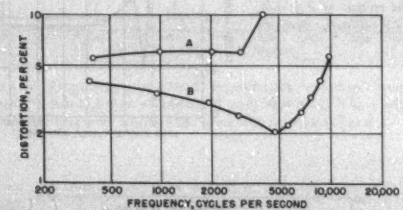

Figure 9. Comparison of third-harmonic distortion and third-order double-tone distortion versus audio frequency at six decibels below saturated output

Curve A: Distortion product is $3f$ (f = 100 per cent)
Curve B: Distortion product is $2f_1-f_2$ (f_1 = 100 per cent)

magnetic tape. Figure 9 shows a comparison of third-harmonic distortion and third-order double-tone distortion versus audio frequency. It is interesting to note that there is a certain band of frequencies where the third-harmonic distortion rises rapidly and the third-order double-tone distortion falls sharply. It should be noted also that the values of double-tone distortion are considerably lower than the corresponding values of third-harmonic distortion. Over a limited range of frequencies, the ratio of these distortions agrees with the value predicted from theoretical considerations. There does not seem to be a valid explanation for the deviation from this ratio at other frequencies. These data all have been corrected on the basis of a system equalized for flat frequency response on playback. Equal values of peak audio current were used in obtaining the data for the two curves shown in Figure 9.

Much more experimental work is required before the double-tone method of measuring distortion can be accepted as a standard measuring technique. Experimental work has indicated that it is valuable for analyzing the distortion in frequency regions where no other method is readily available.

NOISE

Within recent years, the factors which are responsible for the residual background noise in magnetic recording systems have been thoroughly investigated. As a result of these investigations, it is possible to attain signal-to-noise ratios which are higher than can be used effectively in any but professional recording work. The background noise in the better magnetic recording systems is usually so low that the existence of other faults, such as modulation noise, or the transfer effect, are apparent because they are not sufficiently masked by the noise.

Since a magnetic tape which has been thoroughly demagnetized exhibits an extremely low noise level, it is desirable to discuss those factors which tend to raise the noise level of such a tape when actually in use in a practical magnetic recording system.

In a paper presented at a meeting of the Acoustical Society of America, Washington, D. C., April 1948, J. W. Gratian of the Stromberg-Carlson Company discussed some of those factors. It has been found that the noise output increases with, and is nearly proportional to the value of recorded magnetic remanence. Also it has been found that the recorded remanence is approximately proportional to the asymmetry of the wave form of magnetic field intensity in the gap of the recording head over wide ranges of bias field intensities. For our purposes, per cent asymmetry has been defined as the ratio of half the difference between positive and negative peaks to half the sum, expressed in per cent.

A variable asymmetry of the bias wave form is essential when audio recordings are being made. This asymmetry produces the varying recorded remanence which comprises the record but which, in turn, results in an increase in the noise level. This noise level commonly has been known as modulation noise and has been discussed in previous papers. For those portions of the record where there is no audio recording, it is especially important to keep the asymmetry of the bias and erasing fields as low as possible. At a speed of two feet per second, an asymmetry of five per cent introduced into the wave form of field intensity in an erasing head increases the noise level by 23 decibels above the value for zero asymmetry for this particular system. The noise levels reported in this article were measured using an unequalized playback system and a 13.2-kc low-pass filter.

Measurements made at a speed of eight inches per second indicate that the noise introduced by a given per cent asymmetry is about directly proportional to the speed.

Unwanted asymmetry, resulting in higher residual noise levels, is introduced by a certain type of distortion in the bias and erase wave forms, by polarized erasing or recording heads, or by a polarized medium. It is possible for an asymmetrical bias or erase field to be produced even though there is no polarizing influence in the heads or circuits. This is the case when even-harmonic distortion is present in such a phase as to increase the positive peaks and reduce the negative peaks, or vice versa. Experiments have shown that any of the foregoing types of asymmetry can be almost completely compensated by the use of a polarizing influence of opposite sign and of the correct magnitude. This technique has been used to good advantage when making noise studies where a small per cent asymmetry would produce noise levels far greater than those to be measured.

One of the magnetic recording systems which has been advocated by some, because of its simplicity and because of the low power required for erasing, is the system wherein the medium is passed through a saturating unidirectional field prior to its traverse of the recording head. This field not only saturates the medium magnetically but also obliterates any previous recording. In the recording head, the audio signal and high-frequency bias signal are mixed to form a recording field similar to that used in the more conventional ultrasonic bias system of recording, using a demagnetized medium.

In order to compare these two systems, a series of measurements was made to determine the effect on noise and audio output when the bias current is increased. The curves in Figure 10 show the results of these measurements. The sample chosen was one having good high-frequency response. Data for the upper curve were obtained using constant audio recording current. It is apparent that the use of high bias current tends to reduce the noise, but that even with high bias currents there is still a 16-decibel difference between the noise with this system and that which is possible with a demagnetized medium. If a medium which was softer magnetically were used, the residual noise would decrease more rapidly with increase in bias current, but so also would the relative high-frequency response. It is our opinion that any available scheme for

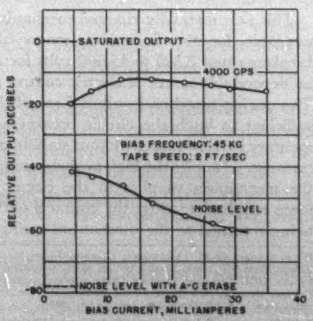

Figure 10. Performance of tape with d-c erase and a-c bias

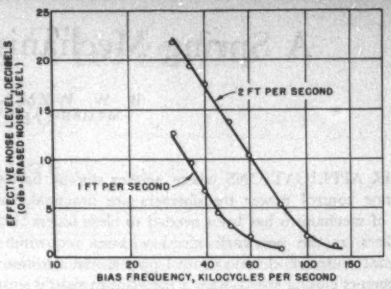

Figure 11. Noise level versus bias frequency for two tape speeds

bringing the recording medium to a neutral or demagnetized state before it traverses the recording field will serve to lessen the noise and thus tend to improve the signal-to-noise ratio. The most satisfactory method seems to be the use of an erasing head energized with alternating current of sufficiently high frequency. Other means are the use of erasing head assemblies which consist of two or more poles producing unidirectional fields of alternating polarity. Since the objective is to produce a neutral magnetic state in the medium, the relative intensities of the unidirectional fields are quite important and the adjustment is rather difficult.

Noise Due to Recorded Erase or Bias Signals. It was stated earlier that noise is a function of the recorded magnetic remanence. Some experimenters have chosen the bias or erase frequency on some basis other than that of obtaining a system with minimum noise. It has been found that any factor which tends to improve the ability of a system to record high-frequency signals also will tend to increase the noise due to the recorded bias unless the bias and erase frequencies are increased, or the recording speed reduced. For example, for equal noise levels, nearly twice as high a bias frequency is required for a given tape sample having a better frequency response than another.

Figure 11 is another illustration of this point. Two curves are shown for a certain medium operated first at a speed of two feet per second, and then at one foot per second. The reduction in noise is much greater than would be anticipated on the basis of the reduction in bandwidth and reduction in output at the lower speed. Similar curves have been obtained for a good recording head and for a poorer one. It then may be concluded that in any of these cases where a change of conditions results in an increase in noise at a given bias frequency, it is because of the higher recorded remanence of the bias under the new conditions.

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A Spring Mechanism for Circuit Breakers

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FOR APPLICATIONS where neither storage batteries nor control power transformers are practical, some type of mechanism has been needed to close oilless circuit breakers at the necessary speed without requiring an external source of electric control power. In addition to the correct closing speed, such a mechanism should supply sufficient energy to close and latch the circuit-breaker contacts under the maximum short-circuit conditions. The mechanism should be sufficiently compact for front mounting on a magne-blast oilless circuit breaker when applied in the vertical lift metal-clad switchgear enclosure. Tripping of the mechanism should be possible from either current transformers, a-c or d-c sources, or manual means. For safety reasons, both closing or tripping operations of the circuit breaker should be possible with the door of the metal-clad unit closed. In order to eliminate the necessity for auxiliary apparatus, such a mechanism should receive its energy from manual motion. To obtain sufficient closing speed, the manual energy supplied by the attendant must be stored and released instantaneously. Manual operation of the mechanism should require a minimum of time and effort from the station attendant.

Figure 1 shows a magne-blast oilless circuit breaker equipped with a new type of manually operated stored-energy mechanism. This mechanism consists essentially of manually charged compression springs connected to a cylindrical mass through a crankshaft and connecting rod. The springs first are charged by the station attendant by means of a manual jacking motion. When fully charged, they may be released. During the first half of the stroke of the springs, most of the energy transferred goes into accelerating the rotating mass. At the end of one-quarter revolution, sufficient energy has been transmitted to the rotating mass to close and latch the circuit-breaker contacts against any value of short-circuit current up to its momentary current rating. This energy is instantly available during the next one-quarter revolution to overcome any retarding forces on the contacts if the circuit breaker should close on a short circuit. At the end of one-half revolution, the circuit breaker is latched completely. If the circuit breaker does not close against a short circuit, most of the energy remains in the rotating mass as the crankshaft goes over center and then returns to the springs in the next one-quarter to one-half revolution. As the mass cannot reverse, this excess energy is retained in the spring which reduces by that amount the energy which the attendant must supply for the next operation. Unlike most mechanisms which transmit a fixed amount of energy to the contacts on all operations, this mechanism provides smooth closing without requiring closing dashpots or buffers to absorb excess energy on no-load operations.

Figure 1. A 15-kv magne-blast oilless circuit breaker, with manually operated spring mechanism, is charged by attendant

A complete series of short-circuit closing and latching tests have been made on the magne-blast circuit breaker equipped with this new mechanism in which the circuit breaker closed and latched successfully short-circuit currents well in excess of the 60,000 amperes rms momentary current rating of the circuit breaker. After the circuit breaker has been closed, the mechanism again may be recharged immediately. If it trips subsequently on short circuit, the mechanism then may be immediately released to reclose the circuit breaker again without waiting for the attendant to recharge the springs. If a small tripping battery or low-current a-c control power source is available, the mechanism may be equipped with an electrical release so that the circuit breaker automatically may be reclosed once from a remote point with automatic reclosing relays.

This new manually charged mechanism therefore makes available for the first time, magne-blast oilless circuit breakers rated 2,300 to 15,000 volts for applications where no dependable source of electric control power is available. The closing speed and output force of this mechanism are sufficient to latch the circuit breaker against its full momentary current rating without stalling or excessive contact burning. Despite the high available output force, however, the mechanism supplies to the circuit breaker only the force required to close the contacts with any excess force being returned to the mechanism springs.

Digest of paper 49-93, "A Manually Operated Spring Mechanism for Medium Oilless Circuit Breakers," recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Léon Charles Thévenin

(1857-1926)

CHARLES SUCHET

Although Thévenin's theorem is used extensively, particularly by communication engineers, little is known of the man himself. This article, translated from the journal of the Administration of Posts, Telegraphs, and Telephones with which Thévenin was associated, outlines some of the highlights of his career.

LÉON THÉVENIN was born in Meaux, France, on March 30, 1857. He distinguished himself as a brilliant student at the École Polytechnique, where he was one of a group graduated in 1876. In 1878 he joined the corps of "telegraph engineers," as they were called at that time, and pursued his entire career in this organization, which he did not leave until he retired in 1914, on the eve of World War I. When he died in 1926, the *Annales des P.T.T.* published an obituary notice, which was signed by Mr. Thomas, Inspector General.[1] This notice contains a detailed account of Thévenin's administrative career. The present article merely gives a concise review of the high points.

Thévenin began as an engineer in the department of long-distance underground cables; later he was connected with the Department of Material and of Construction at the Central Administration (of posts, telegraphs, and telephones), where he took care of the technological problems encountered in the construction of lines and supervised the erection of power lines. During this period he standardized the rules covering the construction of overhead lines. These rules were generally accepted in France and remained in force until the appearance of the Lorain system.

In 1896 Thévenin was made Director of the "École Professionelle Supérieur," which had been organized eight years before and which consisted of two divisions—one training clerical students, the other, student engineers. He left this post in 1901, to be succeeded by Edouard Estaunie, and was appointed manager of the Ateliers du Boulevard Brune. He remained in this position until his retirement.

In addition to his administrative duties, Thévenin continued to devote a considerable portion of his time to teaching, for which he had a liking. Many of the graduates of this school who later became officials remember him as an excellent teacher.

In 1882 he had been appointed to teach a course for the training of inspectors of the engineering department. When the Division of Student Clerks was organized at the École Supérieure, he was asked to teach mathematics. He continued this course, which was a model of precision and clarity, up to 1910. His teaching talents were taken advantage of even outside the Administration of Post, Telegraphs, and Telephones. In 1885 he was asked to teach a course in industrial tools at the École des Hautes Études Commerciales, to which a course in industrial electrical engineering was added in 1914. He taught these two courses until his death.

The Institut National Agronomique engaged Thévenin in 1891 as a tutor (répétiteur) of mechanics, and in 1908, as the leader of seminars in applied mathematics. He continued in these positions to the end of his life. Finally, he became teacher of mathematics at the École Nationale du Génie Rural as soon as the latter institution was organized in 1919.

In connection with his teaching, Thévenin made, at the age of 26, an exhaustive study of the laws of Kirchhoff on electric networks and had occasion to observe the phenomenon which he expressed in his now famous theorem.

Here is how he himself formulated it, in 1883, in the *Annales Télégraphiques:*

> Assuming any system of linear conductors connected in such a manner that to the extremities of each one of them there is connected at least

Léon Charles Thévenin

Essentially full text of an article translated, through the courtesy of the Westinghouse Electric Corporation, from the *Revue des P.T.T. de France* (Paris, France), volume 4, number 1, January–February 1949, pages 1–4.

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one other, a system having some electromotive forces, $E_1, E_2 \ldots\ldots E_n$, no matter how distributed, we consider two points A and A' belonging to the system and having actually the potentials V and V'. If the points A and A' are connected by a wire ABA', which has a resistance r, with no electromotive forces, the potentials of points A and A' assume different (other?) values of V and V', but the current i flowing through this wire is given by the equation

$$i = \frac{V - V'}{r + R}$$

in which R represents the resistance of the original system, this resistance being measured between the points A and A', which are considered to be electrodes.

Thus the theorem of Thévenin provides a very simple method of calculating the current which will flow in a new branch added to a network so as to connect two of its points, A and A'. If there originally is a potential difference $V - V'$ between these two points, and if the resistance equivalent to the whole network included between these two points (minus the electromotive forces) is R, then the current which will flow through the added resistance r located between A and A' will be the same as though the total original circuit were replaced by a simple battery having an electromotive force $V - V'$ and an internal resistance R.

The principle thus formulated is valid not only if the points A and A' are connected to a simple resistance r, but also if they are connected to some new circuit. This conclusion is frequently referred to as the "generalized Thévenin theorem."

The practical consequences of this theorem are not difficult to grasp, since it is constantly necessary to add some new branch to an existing network, and Thévenin's theorem makes it unnecessary to make new calculations. This advantage is further increased by the fact that, since the theorem is based directly upon the laws of Ohm and Kirchhoff, it is applicable, as they are, to alternating current if one resorts to the calculus of imaginaries. This is why it is used by communications engineers even more often than by others.

When Thévenin decided, exultant over his discovery, to report it to the Academy of Sciences, he first spoke of it to Vashy, another famous engineer of the Administration, whom he deeply admired. To his great surprise, Vashy returned his paper with the comment that the law formulated by Thévenin, attractive though it was, was unfortunately wrong. Thévenin then consulted several other scholars well known at the time, and this gave rise to a controversy as to whether his law was consistent with the facts or not. Finally, the theorem was presented to the Academy by Cabanellas.[2]

This controversy shows once more that what is common knowledge today was not considered such when it was still a subject of groping. In any case, it does not detract from his merit.

Thévenin was a humble man and did not realize the importance of his discovery. Shortly before his death he was visited by a friend of his, J. B. Pomey, and was surprised to hear that his theorem had been accepted all over the world and that many applications had been derived from it by the transmission engineers.

Thévenin is remembered as a model engineer and employee, hard-working, of scrupulous morality, strict in his principles but kind at heart. He was very much attached to his family estate at Meaux and lived there all his life, commuting daily to Paris. He remained single but shared his home with a widowed cousin of his mother's and her two children, whom he later adopted. (Much of what we know about his life we owe to Mademoiselle Chaux-Thévenin, his adopted daughter.)

He was a talented violin player and played in private. Another favorite pastime of his was angling, and he bought a boat for this purpose on the Marne River which accounts for his nickname, the Admiral, given to him by his students at the Institut Agronomique.

Léon Thévenin died in Paris, where he had been taken for a treatment, on September 21, 1926. In accordance with his simple tastes, he had left a formal request that no one should accompany him to the cemetery except his family, and that nothing be placed on his coffin but a rose from his garden. This is how he was buried at Meaux on September 23, 1926.

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High-Speed Target Drone

The shooting eyes of the United States Navy's antiaircraft gunners will be sharpened by the antics of a pilotless radio-controlled ram-jet-powered Martin KDM-1 target drone, which will be used to simulate maneuvers of the fastest fighter planes. The KDM-1, built by the Glenn L. Martin Company, Baltimore, Md., is an improved version of the Gorgon IV (shown above). Powered by a 20-inch Marquardt ram-jet engine, the new drone will be launched in air by a twin-engine Navy model JD aircraft. The control system of the KDM-1 can be preset to follow a prescribed course, but may be overridden at any time by a remote-control station. Upon exhaustion of fuel, the drone noses up, a parachute is released, and the target is recovered after dropping into the water

Raising Fault Capacity With Air-Core Reactors

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ASSOCIATE AIEE

IN AN expanding industrial plant, it frequently becomes necessary to increase the transformer capacity at a substation to care for heavier power demands at some particular location. An increase in the power capacity of the substation in turn increases the potential short-circuit kilovolt-amperage that might be applied to the substation bus. An increase in the capacity of the primary system furnishing power to the substation transformer also can increase the potential short-circuit kilovolt-amperage available on the secondary bus.

Any increase in the fault current available at the substation will be reflected in turn throughout the system connected to the substation. In many cases, such an increase will subject high-voltage motor starters, circuit breakers, and other equipment to fault currents in excess of their rating, creating a potential hazard to equipment and to personnel.

Under these conditions, the old equipment can be replaced with new equipment of adequate capacity, but this is expensive and not always necessary.

It is possible to raise the fault capacity of existing motor starters and circuit breakers by addition of current-limiting reactors in the circuits. Air-core reactors with a continuous rating of 600 kva or lower are small enough to be mounted directly in many existing motor-starter cubicles with very little trouble. In many cases, the addition of the reactors will be all that is required to make the starter suitable for use with a bus-fault capacity considerably in excess of the original rating of the starter.

The momentary short-circuit current available at the various component parts of the equipment always must be checked, however, as some of them may be overstressed. If calculations show that any item, such as a current transformer or a contactor, is subjected to currents in excess of its capacity, it usually can be replaced easily and at a relatively low cost.

A cubicle-type control center at the Wood River Refinery of the Shell Oil Company, Inc., consisted of: an incoming line circuit breaker cubicle; a transformer feeder cubicle with an interrupting capacity of 25,000 kva; a 400-horsepower motor starter cubicle rated at a nominal interrupting capacity of 8,000 kva; and a 100-horsepower motor starter with a nominal interrupting capacity of 2,000 kva.

Changes in the power supply to this control center raised the available fault current to approximately 68,000 kva. In order to avoid the cost of replacing this control center, an installation of air-core reactors was made. See Figure 1. Individual reactors of approximately 0.2-ohm reactance were installed in the transformer feeder cubicle and in both motor controller cubicles. The reactors reduced the possible fault in the cubicles to approximately 19,000 kva. No further changes were needed in the transformer feeder cubicle, but the contactors in the starters were still too small to interrupt the fault that might occur. The small contactors were replaced with new ones of adequate capacity. This installation is in operation and similar conversions are being planned.

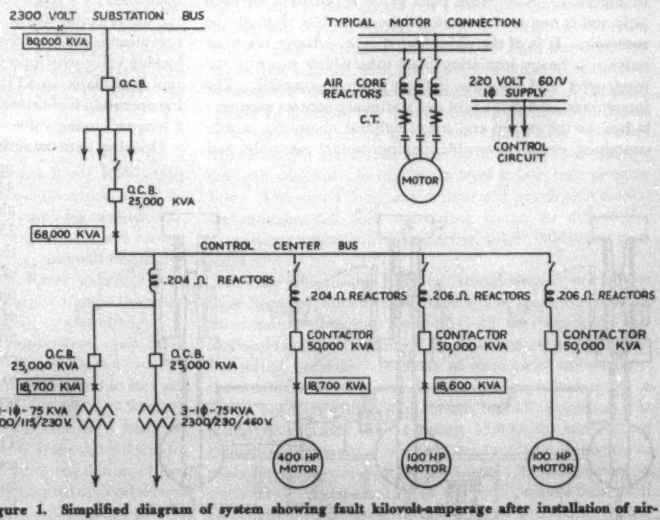

Figure 1. Simplified diagram of system showing fault kilovolt-amperage after installation of air-core reactors

Digest of paper 49-116, "Air-Core Reactors Used to Raise the Fault Capacity of Existing Motor-Starting Equipment," recommended by the AIEE Industrial Control Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949. Not scheduled for publication in AIEE *Transactions*.

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A New 69-Kv Compressed Air Circuit Breaker

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A NEW compressed air circuit breaker has been developed recently for a pioneering installation of outdoor metal-enclosed switchgear for 69-kv service. This circuit breaker, with a current rating of 2,000 amperes and with an interrupting capacity of 3.5 million kva, is of the indoor type mounted in a weatherproof steel enclosure for outdoor service. It has an orifice type of interrupter.

The enclosure includes six capacitor roof bushings with current transformers. The upper ends of the bushings are not exposed but extend into bus enclosures attached to the roof of the circuit breaker enclosure. The center compartment has a built-in control cabinet, accessible from the outside, containing the control panel, auxiliary switches, pressure switches, pressure gauge, and various interlocking elements. Each pole of the circuit breaker is a self-contained unit consisting of an interrupter and isolating switch mounted on a compressed air reservoir.

A diagram of a complete 3-pole circuit breaker is shown in Figure 1. A separate blast valve is provided for each pole and is mounted in a steel tube extending through the reservoir. It is of the air-actuated type. Above the blast valve is a heavy insulating blast tube which supports the interrupter and insulates it from ground potential. The interrupter itself consists of two stationary contact members bolted to the upper and lower exhaust chambers, a self-contained, easily-removable moving-contact assembly, and two insulating tubes serving as spacing members. The entire assembly is clamped together by four spring-loaded insulating tie rods. A shunting resistor, mounted on the side of the interrupter, is connected across the lower pair of contacts. The moving contacts are biased normally to the closed position by springs.

The operation of the blast valves is controlled by a single magnet tripping valve. When the blast valves open, air of 200–250-pounds-per-square-inch pressure enters the space surrounding the moving contacts and forces open first the lower contacts and, after a delay of approximately one cycle, the upper contacts. The air sweeps the arc toward the orifice in the hollow stationary contacts and completely envelops it with a high-velocity turbulent flow which carries the ionized gases through the contacts to the exhaust chambers where they are cooled and released slowly to the atmosphere through mufflers.

The subsequent opening of the three isolating switches is controlled by a single air-operated mechanism mounted on the air reservoir of the middle pole. Air for the opening operation is obtained from the blast tubes through an interlocking valve which prevents opening until air for interruption is available in all three interrupters. Air for the closing operation is obtained directly from the reservoir through a magnet closing valve.

Opening tests on a single-pole unit were made at 60 kv up to 22,500 amperes rms and at 44 kv up to 37,500 amperes rms at air pressures ranging from 200 to 230 pounds per square inch. The time of interruption from energizing of the tripping coil to arc extinction did not exceed 3.5 cycles. A series of 20 interrupting tests with 60 kv on a single pole was made with capacitor currents ranging from 45 to 180 amperes with only one reignition having a maximum instantaneous restored voltage of 1 61 kv. The maximum voltage for the entire series was 168 kv and the maximum circuit breaker time was three cycles. Following a series of 11 close-opening tests at 44 kv with maximum 26,000 amperes rms closed and 21,400 amperes rms interrupted, the circuit breaker withstood successfully a momentary test and a 4-second test of 100,000 amperes rms and 59,400 amperes rms, respectively.

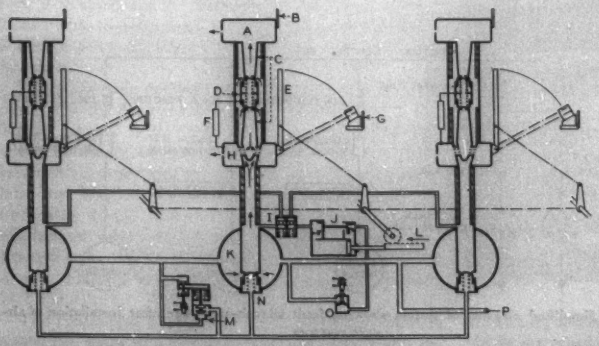

Figure 1. Schematic diagram showing the pneumatic system for a complete 3-pole compressed air circuit breaker

A—Exhaust chamber
B—Line terminal
C—Stationary contacts
D—Moving contact assembly
E—Isolating switch
F—Shunting resistor
G—Line terminal
H—Exhaust chamber
I—Interlocking valve
J—Operating mechanism
K—Compressed air reservoir
L—Close
M—Tripping valve
N—Blast valve
O—Closing valve
P—From compressed air supply

Digest of paper 49-94, "A New 69-Kv Compressed Air Circuit Breaker," recommended by the AIEE Switchgear Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Garrison Dam Power

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One of several large federal power projects on the Missouri River, the Garrison Dam when completed will produce an average annual gross energy of 1,600,000,000 kilowatt-hours. A number of interesting and unusual features to be incorporated in the project are discussed.

THE SUBJECT, Garrison Dam power, in its broader aspect covers more than a generator, a prime mover, and some water flowing through a pipe. It goes back to man's earliest dreams of harnessing mighty rivers to do his drudgery and obey his commands. The dream of corralling the sometimes peaceful, sometimes destructive, but always unpredictable Missouri River is not new with the Corps of Engineers. In fact, as far back as the year 1900 the Corps was investigating advantageous sites for dams across its broad valleys. It was not until 1943, however, that a comprehensive basin plan for flood control, navigation, power, and other purposes was formulated by the Corps. In the following year the Bureau of Reclamation recommended a plan for basin-wide development for irrigation, power, and other purposes. The reports of the two agencies were integrated, and Congress in the Flood Control Act of December 22, 1944, approved the co-ordinated plan commonly known as the Pick–Sloan Plan, of which the Garrison Dam is one of the key units.

DAM AND APPURTENANCES

The dam is located on the Missouri River 1,454 miles above its mouth and 76 miles above Bismarck, N. Dak. (Figure 1). It will be of compacted earth-fill construction, will rise almost 200 feet above the stream bed, will have a maximum width of $^1/_2$ mile at its base, and will extend for almost $2^1/_2$ miles across the Missouri River Valley (Figure 2). A concrete chute-type spillway located in the left abutment of the dam will be approximately 1,440 feet wide and as now planned will contain 29 tainter-type crest gates each 40 feet long and 29 feet high. The discharge capacity of the spillway will be in excess of 800,000 cubic feet per second, approximately 2 $^1/_2$ times the maximum flood on record. This spillway is designed to release, at a safe level below the top of the dam, the inflow from the maximum flood that can possibly occur. Normal regulation of discharges from the reservoir, including control of flood waters equal to the maximum flood on record, will be accomplished by release through tunnels in the outlet works, without resorting to use of this spillway.

RESERVOIR AND ITS OPERATION

The reservoir formed by this dam will extend along the Missouri River in a northwesterly direction approximately 200 miles, to within 9 miles of the mouth of the Yellowstone River and to within 13 miles of the Montana North Dakota state line. It will flood approximately 390,000 acres and will have a shore line of approximately 1,500 miles. Storage in the reservoir will be divided horizontally into three major zones. The lowest, commonly referred to as dead storage zone, will contain 4,900,000 acre-feet. As now planned for ultimate conditions (all authorized projects in Missouri Basin plan completed and operating) the middle, or the multipurpose zone, will contain 13,850,000 acre-feet.

The upper 12 feet, comprising the flood control zone, will contain 4,250,000 acre-feet. During most years, when normal stream flow conditions prevail, the reservoir water surface will remain within the 12-foot range of the flood control zone. Releases will be made from the reservoir during late summer, fall, and winter in sufficient quantities to bring the water surface down to the bottom of the flood control zone before the spring breakup each year. Excess flood run-off occurring during the March and June rises will be caught and stored in the flood control zone and the reservoir will reach its maximum level in late June or early July. The stored flood waters then will be released during the summer, fall, and succeeding winter as needed for navigation, irrigation, hydroelectric power, and other purposes.

If more flood water has been stored than is needed for these purposes, additional releases will be made through the flood control tunnels to assure that the reservoir water surface will reach the bottom of the flood control zone prior to the spring breakup. In years of subnormal stream flow, the middle or multipurpose zone will be called upon to make up deficiencies in run-off for all purposes. As stated before, this zone contains 13,850,000 acre-feet or enough water, if there were no flow into the reservoir, to generate approximately 1,700,000,000 kilowatt-hours of electricity. Water used from the multipurpose zone will be replaced with excess flood waters of succeeding years. The storage available in this zone is capable of meeting water needs during an extreme drought period such as that of the 1930's and still permit maintenance of a minimum power head of approximately 100 feet.

OUTLET WORKS

As previously stated, releases from the pool normally will be made through the outlet works, which will be located in the west abutment of the dam (Figure 3). It will consist of five 29-foot tunnels, one 26-foot tunnel, two 22-foot tunnels,

An address presented before a joint meeting of the Red River Valley Division of the AIEE Minnesota Section and the Fargo Engineers' Club, held in Fargo, N. Dak., March 19, 1949.

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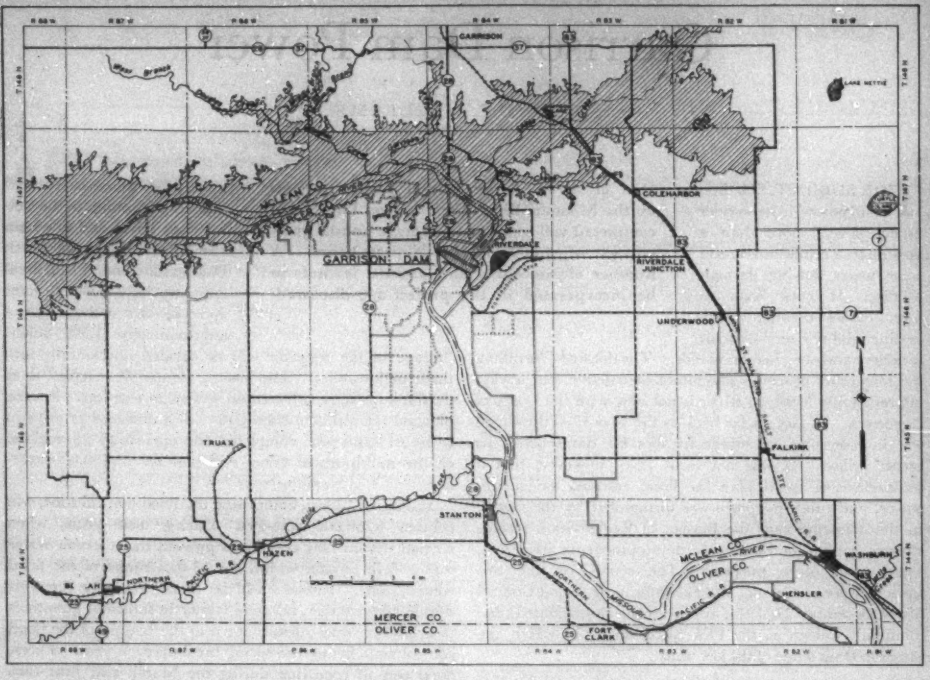


Figure 1. Map showing the location of the Garrison Dam on the Missouri River, 76 miles above Bismarck, N. Dak.

the intake structure, gates, and associated equipment for controlling releases through the tunnels. The intake structure will be approximately 200 feet high, and will house the three 18 by 24 $^1/_2$ foot tainter gates for regulating the flow into the three flood control tunnels and the ten 12 by 26 foot tractor-type vertical lift gates for closing the five power tunnels (Figures 4 and 5). A pier at the upstream end of the power tunnels divides them into two sections permitting use of two smaller gates instead of one large one. The gate house at the top of the structure will be 525 feet long, 51 feet wide, and 60 feet high. It will contain the individual operating machinery and controls for the gates, a 3,000-kva substation and a 150-kw diesel-electric standby unit.

The eight tunnels will be required initially for diversion of the river around the dam during the period while the dam is being placed in the river channel. After diversion, the three smaller tunnels will be used for flood control and for the release of water necessary to maintain river flow during periods when the power plant is not in operation. The vertical lift gates in the five 29-foot power tunnels will be closed and a 24-foot steel penstock installed in each tunnel to supply water to the turbines.

TAINTER GATES

The Garrison Dam will be the first high-head project to employ tainter-type gates for normal flow regulation at the upstream end of long control tunnels. Upstream regulation is less expensive to install than downstream regulation, due to elimination of the steel tunnel lining required when gates are located downstream. This type of regulation has been avoided heretofore because gates hydraulically suited for this use had not been developed. Tainter gates, except for the difficulty in sealing under high heads, have the desired hydraulic characteristics and the decision to use them on this project was influenced by the development in our office of a pneumatic-type seal which effectively closes the openings around the top and sides of the gates for all gate openings without introducing the objectionable friction and other difficulties common to standard types of seals. Gates in the upstream end of the power tunnels do not present any particular problem since they are not used at part opening to regulate the flow, and the velocities through these gates are relatively low.

SURGE TANKS

The penstocks will be over 1,500 feet long and surge tanks will be required near the downstream end in order to ob-

tain satisfactory speed regulation without causing prohibitive water hammer and pressure rises in the penstocks. Present plans contemplate two surge tanks 65 feet in diameter connected to each penstock to obtain hydraulic stability in the penstock system. One 92-foot surge tank would accomplish the same purpose, but the 75-foot spacing of power units and practical considerations in structural design dictated the use of two smaller tanks instead.

POWER PLANT AND APPURTENANCES

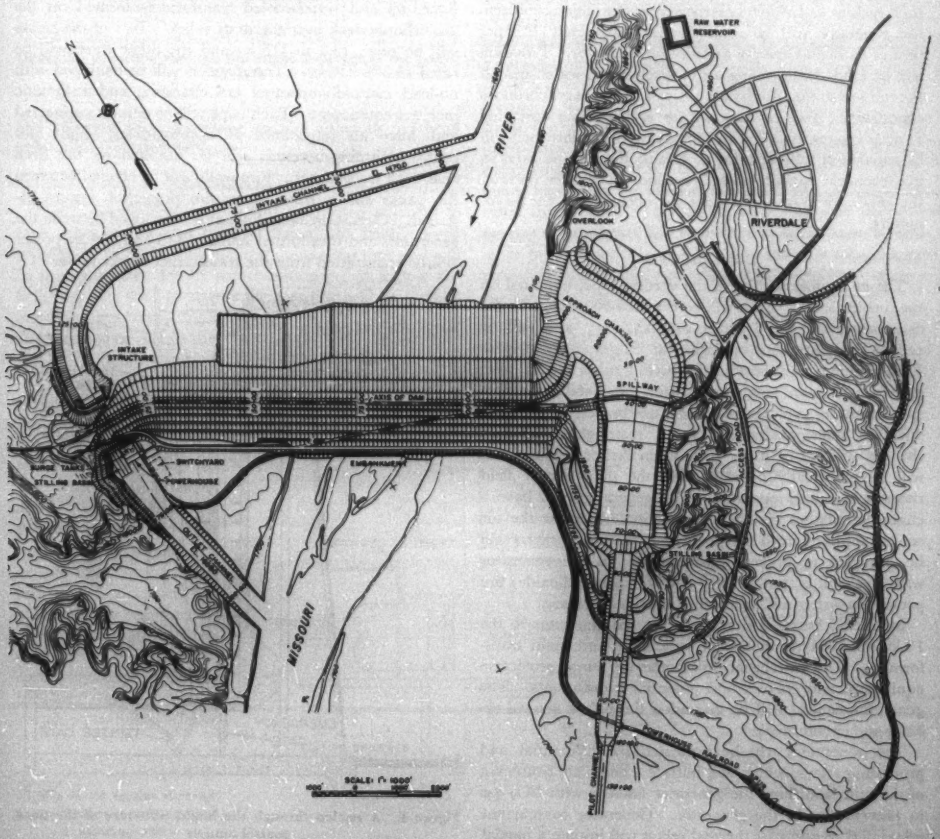
The powerhouse will be located 125 feet downstream from the surge tanks and ultimately will house five main power generating units, auxiliary equipment, and the shops and offices required for operation of the plant. The power plant will have an ultimate rated capacity of 400,000 kw. The dependable generating capacity based on minimum head and flow conditions, as might be experienced during severe drought years, will be about 210,000 kw. The turbines will operate at net heads ranging from 100 to 184 feet. The average net operating head will be approximately 160 feet and the average annual gross energy produced will be approximately 1,600,000,000 kilowatt-hours, of which 900,000,000 will be primary power and 700,000,000 secondary or dump power. It is planned that three of the five main turbines will be installed initially, and the remaining two will be installed as power requirements demand (Figure 6).

Final design of the Garrison power plant has not yet been completed, and none of the major generating equipment has been purchased. The following information and data, therefore, are approximate, based on well advanced preliminary design studies.

TURBINES

The turbines will be of the Francis or reaction type, and will have a maximum diameter across the scroll case of

Figure 2. Plan view of the Garrison Dam and reservoir



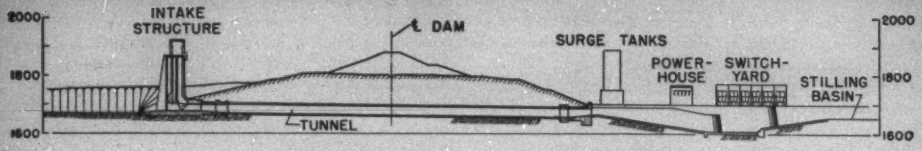


Figure 3. Profile of the outlet works of the Garrison Dam

approximately 66 feet. The runners will have a diameter of approximately 210 inches and probably will be too large to ship in one piece. If so, these runners will be built in sections and securely fastened together in the field. Each of the turbines will be rated 88,000 horsepower when operating at or near "best gate" at 90 rpm under a net head of 150 feet and will have a guaranteed full gate capacity of 55,500 horsepower when operating under a net head of 100 feet.

Provisions will be made for limiting the output of each turbine to 134,000 horsepower, under which condition the generator will be producing approximately 115 per cent of its rated capacity at unity power factor. Provision will be made for injecting air to displace the water around the runners so that the generators can be run as synchronous condensers. Two servomotors for each turbine operating at oil pressures from 250 to 300 pounds per square inch will be capable of fully opening or closing the turbine gates in five seconds. Actuators which are located between units on the generator floor will control the operation of the servomotors.

GENERATORS

The generators will be of the vertical type, mounted on the turbine shaft. Each will be rated 80,000 kw, at 95 per cent power factor, 60 cycles, and 13.8 kv; and will be capable of continuous operation at 15 per cent overload. Each generator will be equipped with a main exciter, pilot exciter, permanent magnet generator, overspeed and underspeed switches, voltage regulator, air brakes, and an oil-operated rotor jacking device. A main generator field rheostat will not be used. The main exciter field rheostat will be electrically operated and the pilot exciter field rheostat manually operated. The generators will have a closed ventilation system with cooling water for the air coolers supplied from the penstocks. Electric heaters will be provided to prevent condensation on the generator when the unit is shut down. A CO_2 (carbon dioxide) fire protection system will be installed in each generator.

Metalclad busses will extend from the generator to the 15-kv cubicle-type metalclad switchgear and main transformers. The switchgear will house the surge protection equipment and current and potential transformers. The generator neutral will be grounded through a neutral reactor and circuit breaker.

The generators will be protected by differential and grounding relays, which will initiate a complete shutdown of the unit, and flood the generator housing with CO_2 gas to prevent fire in the generator. Generator overcurrent relays and transformer thermal relays will initiate a partial shutdown by disconnecting the unit from the line and reducing the generator speed. Other troubles such as low oil pressure, high bearing temperature, transformer spray release, and operation of transformer differential protection will initiate shutdown of the unit but will not flood the generator with CO_2.

TRANSFORMERS

Each generator will be connected to a 100,000-kva transformer bank consisting of three single-phase 33,333-kva forced-oil and water-cooled transformers located on the powerhouse deck over the draft tubes. Two of the banks will be rated 13.2 to 115 kv and the other three will be rated 13.2 to 230 kv. Transformers will be equipped with no-load manually-operated tap changers, and automatic inert gas equipment. Each bank will be delta-Y connected and have an impedance of approximately eight per cent. Lightning arresters will be installed on the deck near each transformer. Fire walls will be erected between the banks and a water spray fire protection system installed. Circuit breakers will not be employed between the generators and transformer banks. 115 and 230 kv power will be transmitted from the transformer banks to the 115-

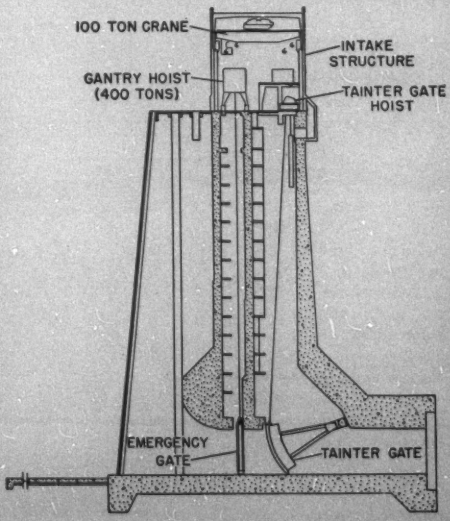


Figure 4. A section through the intake structure of the flood control tunnels

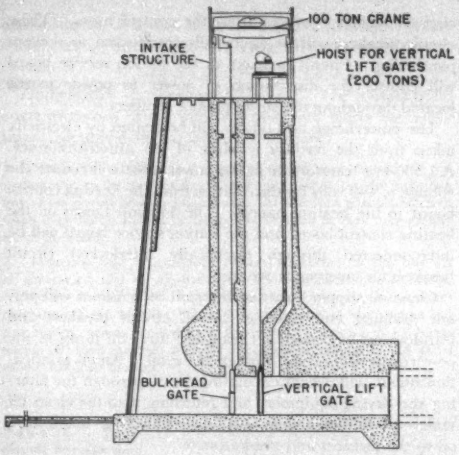


Fig. 5

Figure 5. A section through the intake structure of the power tunnels

and 230-kv outdoor switching stations either by overhead lines or oil-insulated cables.

SWTICHYARDS

The two switching stations will be located adjacent to each other on the east bank of the stilling basin. Each station will be of the sectionalized double-bus type and will be interconnected by an autotransformer. It is now anticipated that the 115-kv switching station will be divided into two generator bays and five line bays, and the 230-kv switching station will be divided into three generator bays and three line bays. A modified "breaker and a half" system of switching will be used with circuit breakers and motor - operated switches so arranged that the transfer of a generator or line from the preferred bus to the auxiliary bus automatically transfers its tripping and closing circuits to the auxiliary circuit breaker. Circuit breakers in the 115-kv switching station will have an interrupting capacity of 3,500,000 kva at 5-cycle opening time and circuit breakers in the 230-kv station will have an interrupting capacity of 3,500,000 kva at 3-cycle opening time. Line and transfer circuit breakers in both stations will be equipped for one time 20-cycle reclosing. The autotransformer bank which interconnects the 115- and 230-kv switching stations will be rated 75,000/100,000 kva, and will be of the self-cooled forced-air-cooled type. Power will be taken from the tertiary winding of this transformer bank to feed the intake structure, the town of Riverdale, the spillway, and the heating of the powerhouse.

CONTROLS

Supervision and control of generating units, plant auxiliaries, and switching will be centralized in the control room located in the powerhouse. This room will contain a main control benchboard, a main instrument and relay board, a station recording load frequency control board, and a d-c control board. The bench board will be located in front of the operator's desk and will be divided into line and generator panels. Line panels on the left of the board will contain control switches and indicating lights for oil circuit breakers, motor-operated disconnect switches, and so on. Generator panels on the right of the board will contain controls for speed, voltage, power factor, synchronizing, generator transfer, emergency shutdown, and so forth. Panels in the main instrument and relay board will be located behind corresponding panels in the bench board with the instruments located on the front of the board and the relays located in the rear. The station recording and load frequency control board will be located to the left and at right angle to the main boards. It will consist of a temperature recording, hydraulic recording, load frequency control cubicle for each unit, and a frequency recorder control,

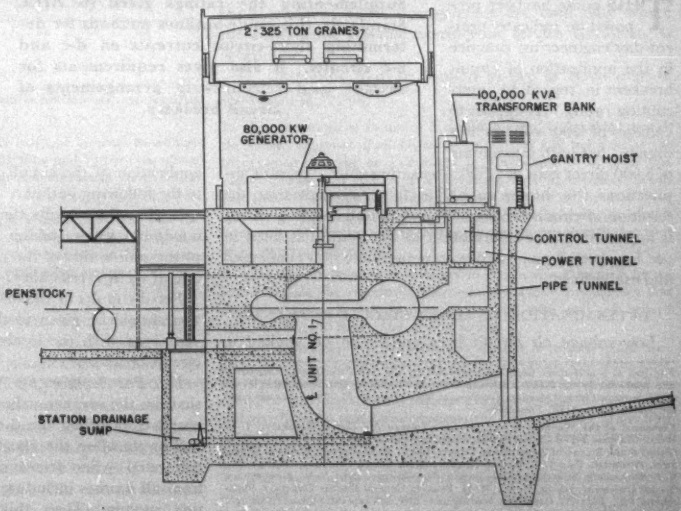


Figure 6. A section through the powerhouse unit number 1, showing parts

totalizing load recorder, and a master controller cubicle common to all units. The d-c control board will be located to the right and at right angle to the main control boards and will control charging current to the station service battery, the charging equipment, the inverter for carrier current, and the distribution of the d-c power. Control cubicles for the station service transformers will also line up with the d-c switchboard. A combination terminal room and spreader room located directly below the control room will connect with the control tunnels. Cables from the control room will be brought down through the floor to the spreader room where they will be laid in trays which are running through the tunnels to the operating equipment.

STATION SERVICE FACILITIES

Electric power for powerhouse lighting and for the operation of auxiliary equipment in the powerhouse will be provided by two transformers connected to separate generator busses. The 440-volt side of these transformers will be throat-connected to the station service switchboard through circuit breakers operated from the control room. These circuit breakers will be electrically interlocked to prevent paralleling. Circuit breakers in the station service board will control the distribution of power to power panels located throughout the power plant and offices.

The powerhouse and offices will be heated by electricity taken from the tertiary winding of the autotransformer. A 1,500-kva transformer in the powerhouse will reduce the voltage to 440 volts for distribution from the heating control board to the heating panels. The 440-volt busses on the heating control board and the station service board will be interconnected through electrically interlocked circuit breakers for emergency service.

Clean oil supply lines and dirty oil return lines will permit draining and refilling the oil circuit breakers and transformers as desired. Clean and dirty oil tanks in the powerhouse will permit storage of the oil. An oil purification system will permit circulating the oil through the filtering and drying equipment and returning it to the clean oil tanks. A similar system will be provided for lubricating oil to the turbines and generators.

Guide for Applying Low-Voltage Air Circuit Breakers

AN AIEE COMMITTEE REPORT

Supplementing the ratings given in AIEE Standards, this guide outlines methods for determining short-circuit currents on d-c and a-c circuits. It also gives requirements for cascade and selective-trip arrangements of circuit breakers.

THIS guide has been prepared to indicate present-day engineering practice in the application of circuit breakers in regard to interrupting rating. It applies to voltages of 600 volts or less usually, but with maximums of 3,000 direct volts or 1,500 alternating volts. In most applications the power supply is large enough that the selection of circuit breakers of proper interrupting rating is important. The information in the guide has been in use for several years, and is presented here in a condensed and usable form.

DETERMINATION OF SHORT-CIRCUIT CURRENTS

Low-voltage air circuit breakers are to be applied to circuits in the usual manner by observing that the ratings defined in the Standards are not exceeded. The interrupting ratings, as given in the Standard, assume that the maximum short-circuit current available at the point of application of the circuit breaker, is calculated according to the following outline.

I. For d-c circuits the current calculated shall be the maximum value, taking into account all resistance up to the source side of the circuit breaker but not including any of its own resistance.

For d-c faults of 100,000 amperes and above, consideration should be given to the rate of rise of the current as compared with the interrupting speed and rating of the circuit breakers.

II. For 3-phase a-c circuits, the current calculated shall be the average value of the three phases of the total current, including the d-c component at an instant one-half cycle after the short circuit occurs. This value is computed by first determining the total symmetrical current from all sources including synchronous motors and induction motors. Then this total symmetrical current is

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Personnel of the Working Group for Low-Voltage Air Circuit Breakers: J. D. Wood, *Chairman*, I-T-E Circuit Breaker Company, Philadelphia, Pa.; C. L. Killgore, United States Bureau of Reclamation, Denver, Colo.; F. W. Cramer, Carnegie Illinois Steel, Pittsburgh, Pa.; J. C. Woods, Commonwealth Edison Company, Chicago, Ill.; V. E. Schlosberg, Inland Steel Corporation, East Chicago, Ind.; S. W. Zimmerman, Cornell University, Ithaca, N. Y.; R. M. Bennett, General Electric Company, Philadelphia, Pa.; and G. G. Grisinger, Westinghouse Electric Corporation, East Pittsburgh, Pa.

multiplied by a factor to determine the average 3-phase current at an instant one-half cycle after the short circuit occurs.

Determination of Symmetrical Current.[1] The symmetrical current consists of the sum of system and motor contributions, calculated in the following manner:

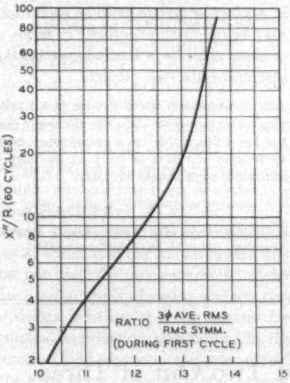
1. System contribution is determined for all sources and all impedances up to the source side of the circuit breaker, but not including any of the circuit breaker impedance. At 600 volts and below, even small impedances should be taken into account as they may greatly affect the result.

2. Induction and synchronous motors connected to the bus act as generators, and at one-half cycle after the short circuit occurs, contribute current which may be calculated from the subtransient reactance of the motor. Where the reactances of the motors are not known, values are assumed for induction motors of 3.6 times motor full-load current, and for synchronous motors of 4.8 times motor full-load current.

Figure 1. Short-circuit current decrement

Ratio of 3-phase average rms total current to rms symmetrical current during first cycle of fault current flow. Curve represents maximum ratio for a simultaneous 3-phase fault with initial components of:

Phase	A	B	C
Alternating symmetrical current	1.0	1.0	1.0
Direct current	1.42	0.71	0.71



When the motor load of the installation is not known, assumptions may be based on system voltages.

For system voltage of 120 and 120/208 volts, it is usual to assume that the connected load is 50 per cent lighting and 50 per cent motor load. This corresponds to an equivalent symmetrical contribution of twice the full connected load.

For system voltage of 240 to 600 volts, it is usual to assume that the load is 100 per cent motor load and, in the absence of exact information, that the motors are 25 per cent synchronous and 75 per cent induction. This corresponds to an equivalent symmetrical contribution of four times the full connected load.

Determination of Asymmetrical Current. The asymmetrical or total rms current including the d-c component, is determined by multiplying the symmetrical current as obtained from the preceding method by a factor to account for the increase in the average 3-phase current caused by the presence of the d-c component. While this factor depends on the X/R ratio of the total impedance to the point of fault, a good approximation is obtained by the use of a multiplying factor of 1.25. The use of this approximate factor, in preference to the determination of the exact factor obtaining for the specific X/R ratio for each low-voltage circuit breaker application, is generally accepted practice. This factor of 1.25 corresponds to a ratio of 11.72. For more exact calculations the proper factor may be taken from Figure 1.

III. For single-phase a-c circuits, the current is calculated in the same manner as that used for 3-phase circuits, as the maximum asymmetrical current in a single-phase circuit is identical with the current in the highest phase of a 3-phase circuit.

Example. With a ratio X/R equal to 11.72 the average asymmetrical current of the three phases is 1.25 times the symmetrical current. One phase may be fully offset, and the asymmetrical current in it will be 1.48 times the symmetrical current. A circuit breaker rated for three phase using the factor 1.25 has taken into account that the current in one phase may be equal to 1.48 times the symmetrical current. The factor 1.25 therefore should be used for single-phase circuits as well as for 3-phase circuits.

REQUIREMENTS FOR CIRCUIT BREAKERS IN CASCADE ARRANGEMENT

Where continuity of service is not required, properly selected circuit breakers may be used in cascade arrangement. Circuit breakers are considered to be in cascade when a plurality of low-voltage air circuit breakers are connected in series in a distribution system, and the circuit breakers beyond those nearest to the source are applied in the following correlated manner.

In this cascade arrangement, circuit breakers toward the source are provided with instantaneous tripping devices for current values which may occur for faults beyond other circuit breakers nearer the load. Hence, circuit breakers in the series other than the circuit breaker closest to a fault, may trip and interrupt loads on other than the faulty circuit. Such arrangements are used only where the consequent possible sacrifice in service continuity is acceptable.

I. Cascading shall be limited to two or three steps of interrupting rating.

1. The interrupting rating of a circuit breaker or breakers nearest the source of power shall be equal to at least 100 per cent of the short-circuit current as calculated in accordance with preceding paragraphs of this guide. The circuit breaker or breakers in this step shall be equipped with instantaneous trips set to trip at a value of current that will give back-up protection whenever the circuit breaker in the next lower step carries current greater than 80 per cent of its interrupting rating.

2. The circuit breaker or breakers in the second step shall be selected so that the calculated short-circuit current through the first step plus motor contribution in the second step, will not exceed 200 per cent of their interrupting rating.

For the second step of a 2-step cascade, the circuit breakers shall have an instantaneous trip set above the starting inrush current of the load. For the second step of a 3-step cascade, the circuit breakers shall be equipped with instantaneous trips set to trip at a value of current that will give back-up protection whenever the circuit breaker in the next lower step carries current greater than 80 per cent of its interrupting rating.

3. The circuit breaker or breakers in the third step shall be selected so that the calculated short-circuit current through the first step, plus motor contribution of the second and third step, will not exceed

300 per cent of their interrupting rating. They shall have instantaneous trips set above the starting inrush current of the circuit.

II. All circuit breakers subjected to fault currents in excess of their interrupting rating shall be electrically operated from a remote position only, to provide protection for the operator when closing against fault current.

III. Where cascading is proposed, recommendations shall be obtained from the manufacturer in order to insure proper co-ordination between circuit breakers. Molded case circuit breakers are not recommended for use in cascade.

IV. The operation of circuit breakers in excess of their interrupting rating is limited to one interruption, after which inspection or replacement may be required.

REQUIREMENT FOR CIRCUIT BREAKERS IN SELECTIVE TRIP ARRANGEMENT

Where continuity of service is desired, selective tripping arrangements of full-rated circuit breakers are required. Selective overcurrent tripping is the application of circuit breakers in series so that of the circuit breakers carrying fault currents, only the one nearest the fault opens to remove the overcurrent.

Properly selected air circuit breakers may be applied to low-voltage circuits to obtain selective tripping. The following requirements shall be observed:

I. Each air circuit breaker must have an interrupting rating equal to or greater than the available fault current at the point of application.

II. Except for the one farthest removed from source of power, each air circuit breaker must have a short-time rating equal to or greater than the available current at the point of application.

III. The time–current characteristic of each air circuit breaker at all values of available overcurrent, shall be such as to insure that the circuit breaker nearest the fault shall function to remove the overcurrent conditions. Those nearer the source shall remain closed and continue to carry the remaining load current.

IV. To insure that each circuit breaker shall function to meet these requirements, the time–current characteristics of associated circuit breakers must not overlap. The pickup settings and time delay bands of both the long-time and short-time delay elements must be properly selected.

V. Manually-operated circuit breakers shall be limited to application in which delayed tripping requirements do not exceed 15,000 amperes or 15 times the coil rating, whichever is greater.

VI. The time–current characteristics of circuit breakers in a selective system shall be such that four circuit breakers may be operated selectively in series when required. One of these shall be a load circuit breaker equipped with an instantaneous trip element.

Note: Attention is directed to the fact that operation of selective tripping requires co-ordination with the rest of the system. As an example, the low-voltage side of a transformer bank requires that, in the application of relays or fuses on the high-voltage side, proper co-ordinating steps should be taken.

REFERENCE

1. Simplified Calculation of Fault Currents, AIEE Switchgear Committee. AIEE *Transactions*, volume 67, part 2, 1948, pages 1433–5.

The Fallacy of the Best Two Out of Three

In scientific and engineering investigations one or two measurements of an unknown quantity is seldom considered sufficient. Three measurements is the minimum number that can conceivably reveal one of the measurements to be unreliable in a new experimental situation. Intuition suggests that if two of the three measurements are in close agreement while the third stands apart considerably removed from either of the others, then there may be grounds for suspecting and perhaps rejecting the third value. In terms of the difference between the two in good agreement, how different may the third measurement be before it should be suspected?

An approximate solution has been obtained in the National Bureau of Standard's Statistical Engineering Laboratory through an empirical study of triads drawn at random from a group of 400 measurements constructed to conform to the characteristics of a normally distributed set entirely free from any gross errors. In this way, it is possible to examine a great many sets of three measurements and to determine how often the two differences between adjacent values in a set of three measurements will bear a ratio of 5 to 1, 10 to 1, 20 to 1, or any other ratio that might be considered unlikely in the normal course of events. The Bureau's findings are shown in the table. It is important to note that high ratios can result when two of the readings are very close while the third is not far removed.

Ratio of Large to Small Difference	Frequency in 400 Sets	Theoretical Frequency
4.0 or more	149	145.2
9.0 or more	76	69.4
19.0 or more	38	33.9

These results reveal that in an average of one out of every 12 sets, one of the measurements will be at least 19 times farther away from its neighbor than the difference separating the two closest. Since in every 12 sets, one shows such a spacing for measurements with no gross observational errors, it appears that measurements which should be retained are often dropped from the engineer's tabulations of data.

Gas Turbines in Stationary Power Generation

F. T. HAGUE
ASSOCIATE AIEE

THE ULTIMATE possibilities of gas turbines have been publicized widely. Many of the developments on which improved performance at an economic cost are dependent, are now in such a preliminary stage of research that it is impossible to predict the extent to which these ultimately will be incorporated in commercial gas turbines. This very uncertainty makes the future of the gas turbine intriguing to engineers.

The gas turbine is an economical and practical reality in its present stage of development for many types of application. It is pre-eminent in the aircraft power-plant field because it does a better job than competitive power plants. Doing a better job means that the integration and evaluation of its first cost, size, cost of power generation, life, maintenance, and reliability, makes it more attractive than any other type of plant. Gas turbines will compete with other types of power plants only when they "do a better job."

In the stationary power-generation field, the gas turbine plant and the steam plant may be compared on an economic basis by arbitrarily assuming that the life, maintenance, and reliability characteristics can be made equal, leaving first cost and cost of power generation as the predominant criteria. Such an economic analysis has been described by A. Meldahl in the *Brown Boveri Review* of October 1946, resulting in a simple diagram which permits the determination of the plant load factor at which two plants of different first cost have the same cost per unit of power generated for any specific fuel costs. Such an analysis of steam and gas turbine plants of current design indicates that the present-day gas turbine has economical application possibilities in the stationary power generation field whenever the price of fuel is sufficiently low or the load factor is less than ten per cent, and then only when the gas turbine plant first cost is relatively low.

This is a reasonably encouraging outlook for a new type of power plant, and it indicates the two lines along which the gas turbine probably will be introduced into the power-generation field. It also serves to give a quantitative answer to the usual question of how much improvement in the gas turbine plant's "first cost versus power generating cost" relationship must be achieved before it can challenge the steam plant as an economical base-load operating unit for any specific fuel cost. It appears that the gas turbine plant initially will serve the power-generation field not by challenging the steam plant, but by supplementing it.

Gas turbines for stationary power generation that have been built in both the United States and Europe all are characterized by: either the availability of very cheap fuel, such as cheap oil from pipe lines, or gas costing one-third as much per heat unit as coal; low load factor; or experimental large plants, as in England and France, subsidized by their governments.

There are very few locations in the world that present the same attractive combination of low fuel cost and large industrial electric-power consumption as the cities located near the southern oil and gas fields of the United States. Gas here costs one-third to one-fifth as much as coal. Low fuel costs permit the use of simple plants that are desirable as initial installations of a new type of plant.

In England and France, there is no cheap fuel. This favors the highly efficient higher-cost type of gas turbine. The British Ministry has contracts for two 15,000-kw open-cycle units for Newcastle and Manchester, and a 12,500-kw Escher-Wyss-type closed-cycle unit for Glasgow. The French Ministry is financing three installations in the suburbs of Paris, a 12,500-kw Escher-Wyss-type closed-cycle unit, a 15,000-kw combined gas and steam turbine unit, and a 2,000-kw open-cycle unit. None of these installations is as economical as base-load stations burning oil.

These English and French plants are a government investment in gas turbine development for the purpose of providing large-capacity test plants without which no real progress in this field ultimately can be made. Our industrial firms would have to invest several million dollars in a similar program, without reasonable assurance of an economic market for the end product, to gain comparable experience to that which will flow from these government programs.

It is an almost unanimous opinion both here and abroad that there remains much work in research and development before the gas turbine can be considered as a practical and economical power plant for base-load power generation in competition with coal-fired steam plants. It will be found very attractive as a peak load plant. It must burn coal if it is to compete with coal-burning base-load steam plants. Its cycle efficiency increases three times as fast as a steam plant for higher top temperatures, so that its future promise for lower-cost power generation is largely tied up with the development and construction of materials that can handle temperatures 300 to 500 degrees Fahrenheit higher than the present 1,250-degree-Fahrenheit level. The limited availability at times of national emergency of the rare elements essential to higher temperature materials is being given consideration in this materials research.

Continuing development of the gas turbine's major components—compressors, combusters, and turbines—is being accelerated in the gas turbine aviation engine program by the availability of government-sponsored component research laboratories. At the same time several manufacturers are acquiring essential practical experience by making applications of gas turbine plants in those fields where it is now economical, thereby laying the groundwork to use important research developments as they become available.

Digest of paper 49-115, "Gas Turbines in Stationary Power Generation," recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Induction Motors for Synchronized Drives

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MEMBER AIEE

THERE are two types of synchronized drives of two or more mechanically independent shafts commonly known: one is the "power selsyn" or "synchro-tie;" and the other might be called the "simplified selsyn." The first system uses, besides one or more prime movers, individual selsyn motors for synchronizing. The analysis and application of this type is very well covered in literature. With the simplified-selsyn system, each single shaft is driven by its individual motor, a wound-rotor induction motor, and these motors themselves are used for achieving a synchronized drive, without any additional selsyn motors. So far, the published analyses of this system are very poor and very little information, if any, can be obtained from the literature, which could be used as a guide for planning of such drives. Recognizing this situation, the Armour Research Foundation of the Illinois Institute of Technology made possible the performance of a series of tests which should furnish more basic information on the subject.

Figure 1 shows the wiring of two wound-rotor motors for such a synchronized drive. The slip rings of both motors are interconnected, tying the equivalent rotor phases together and a combined secondary resistor is inserted between the tie leads. The ohmic value of this resistor is important for obtaining a satisfactory operation. The two extreme values of resistance are zero (resistor short-circuited) and infinite (no connection between the rotor tie leads). In the first case, the two motors act as two independent squirrel-cage induction motors without any synchronizing torque, and under different loads the slip of the motors will be different.

In the second case, with no connection between the ties and with the rotors in synchronized position, both rotor voltages are in opposition and cancel each other. No rotor current can flow, no torque can be developed, and the motors do not start. The proper size of this secondary resistor is important. Defining BR as the base rotor resistance, $BR = E_2/\sqrt{3}I_2$, where E_2 is the rotor voltage across rings; I_2 is the rated secondary current. The optimum value of this secondary resistor is around 0.23 BR. With the transmitter motor fully loaded and this resistor, 0.23BR, inserted, a synchronized run is secured if the load of the receiver motor is between a maximum 1.95 rated torque and a minimum 0.2 rated torque. With a greater load, the receiver motor will be stalled, and with a load smaller than minimum, the receiver will speed up to almost synchronous speed.

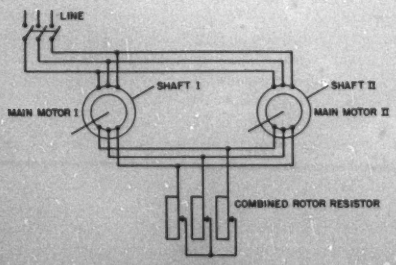

Figure 1. Diagram of a synchronized drive with two duplicate wound-rotor induction motors

The customary stopping by disconnecting the motor primaries from the line is inconvenient, because there is no synchronizing action during the deceleration period. It is recommended that the drive be stopped by opening the combined resistor circuit and leaving the primaries line-connected. The drives come to rest under the influence of the load, friction, and stop brakes, and an appreciable synchronizing torque is maintained during the deceleration period.

To avoid failures in operation, the shortcomings of this system have to be realized. In the first place, the synchronized run is secured, as previously indicated, only if the load differences between the two shafts do not exceed the permissible limit. However, there are very few cases where the normal or accidental load differences (due to frozen bearings, jammed gears, or the like) safely can be predicted. Furthermore, in case of failure of the power supply, there is no synchronizing torque developed and a displacement is very likely. Consequently, in cases where proper alignment is paramount, the following arrangement of safety devices is necessary:

1. Automatic control of the angular displacement between the two rotors can be achieved easily by two small selsyns, each rigidly coupled to one motor, and a conventional differential selsyn between the two. The differential selsyn permits observation of the angular displacement at rest and while running, and develops ample torque for control purposes. For example, it can actuate a sliding contact, which opens, through a contactor, the combined resistor leads, in case the angular displacement exceeds the preset limit.

2. Control of displacement also can be achieved by limit switches.

3. The correct arrangement of the motor overload protection is also important. In case just one of the overload relays trips, all motors have to be stopped. As previously mentioned, it is very convenient not to interrupt the motor primaries with these safety devices, but to disconnect the leads to the secondary tie resistor.

4. Another requirement is provision for realignment. This is achieved by arranging a key-locked switch, which permits operation of only one motor in both directions, and which by-passes all the alignment controls.

Digest of paper 49-119, "Wound-Rotor Induction Motors for Synchronized Drives," recommended by the AIEE Industrial Control Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949. Not scheduled for publication in AIEE *Transactions*.

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Trends in Fluorescent Lamps

WILLARD C. BROWN

A slender green tube 18 inches in length, introduced to illuminating engineers in 1935, is the progenitor of today's vast fluorescent lamp industry. Since that time, the basic methods of operating the tube have changed little. Engineers have improved and elaborated on fundamental system elements, such as ballasts, starters, and cathodes; as a result of their work, a large variety of lamps is available to the public.

IN THE fall of 1935, the Illuminating Engineering Society held its annual convention in Cincinnati. In those days the society had exhibits of light sources and fixtures at its conventions. In the General Electric booth there was shown a green tubular lamp, $1^1/_2$ feet long, somewhat resembling the then popular lumiline lamp, except that this one shone green, with a vivid intensity. The caption on the display said, "The fluorescent lamp—a laboratory development of great promise." It certainly was of great promise! And ever since those days, development has been proceeding at a lively rate.

Then, in November 1936, there came the great Centennial Dinner of the Patent Office in Washington, D. C. Here the new lamps were used publicly for the first time, for illuminating pilasters and decorative elements, and in this way lighting the room.

But it was before a joint meeting of the New York Electrical Society and the New York Sections of the AIEE and the Illuminating Engineering Society that Ward Harrison and S. G. Hibben, made the first public announcement of the lamps being available for general use. That was on April 21, 1938. (See *EE, May '38, p 226.*)

The journal *Lighting and Lamps* reported them as being, ". . . . like lumiline lamps—straight glass tubes, capped at the ends." Three sizes were announced at that time: 15 watts, 18 inches long; 20 watts, 24 inches long; and 30 watts, 36 inches long.

Ward Harrison pointed out that one of their advantages was the production of colored light in huge quantities. He envisioned also particular advantages for the "daylight" and the "white," remarking that the light from the so-called white lamp closely approximated the light from the regular Mazda (filament) lamp, being rather warm in character. Thus, with it objects would appear the same as under filament lamps, except that the "blues" were better with the new lamps. (At that time, 11 years ago, we did not continue long with this warmer white, but now, 10 years later, we seem to be making a fuss over a "new" color of lamp, having a "warm tint," which does just about the same thing).

Dr. Matthew Luckiesch, Director of General Electric's Lighting Research Laboratory at Nela Park, commented: "We have needed artificial daylight. . . . now we have it, and of low brightness compared with the daylight sky . . . . yet comparable in coolness with natural daylight." I, personally, was one of those who thought that the daylight lamp would be the big seller, because that year I had made a survey of New York offices and found over 25 per cent of them with daylight lamps or some form of color correction to bring the light from filament lamps closer to daylight.

In the afore-mentioned history-making meeting of April 1938, it was said that the new source was not a perfect illuminant, for four reasons. They are still of interest to us:

1. It does not run directly from the line—it requires an auxiliary. (Well, fluorescent lamps are arcs, and that is what you usually have to have with an arc, even today.)

2. The auxiliary contains a choke, and chokes notoriously have a poor power factor. (The original auxiliaries did give only about 50 per cent power factor, and there was some fear about the effect of this. Well, this point we have taken care of, with the tulamp ballast, which gives a high power factor. Taking one manufacturer, for example, the General Electric Company, the average power factor of the ballasts it has sold to date is over 85 per cent. So we do not worry so much about power factor today. And the tulamp ballast took care of the question of stroboscopic effect or flicker; we do not hear much about this today either.)

3. Lamps are not available in high wattage; hence it takes a good many units to light a room. (We have made some progress in this direction, as we shall see. But the fluorescent lamp at its best is still inherently a low-wattage device. If we increase the wattage, and keep the same efficiency, it gets rather large in physical size, or very, very long.)

4. Partly because of the low wattage, and partly because the lamps are new and higher in cost than they will be a few years hence, fluorescent lighting, though more efficient, is not less expensive than other more conventional forms of lighting. (We have made great progress in this direction. Just considering lamp efficiency, the progress has been startling in these few years, Figure 1. And life has been increased, and increased.)

Since the beginning, we have devoted our attention to getting larger lamps and in other ways reducing the overall cost of lighting. The period when we began to prepare for World War II found us with a greater variety of lamps, including the 48-inch 40-watt lamp, and with greatly reduced costs of lighting as compared with only two years before. And with the 4-foot lamp, we developed the idea of continuous-row lighting, line sources, and lines of light, all of which are simple, functional, and lower in cost. The first installation of continuous-row lighting was in a General Electric lamp factory in Cleveland in the summer of

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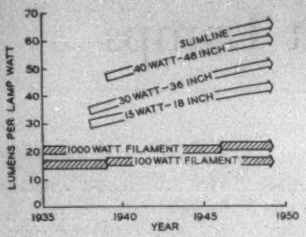

Figure 1. Gains in efficiency of fluorescent lamps since their introduction

1939. The reflectors were home-made, because this kind of equipment was not yet available. You all know what happened.

The 40-watt lamp became the standard light source for our war plants, and it has remained so since the war, for most civilian uses. Today it is the biggest seller, dollar-wise, of all lamps of all kinds—at least of General Electric lamps.

And I should mention the rectified-current lamp, which, you will recall, was widely used by industry, which liked its instant starting and cool blue-white color.

When the war came the War Production Board stopped development of new lamps—even the color was frozen at white and daylight. The manufacture of new rectified-current lighting units was stopped entirely because they required more steel and copper for their auxfliaries and more mercury for the lamps, a very scarce material in time of war.

I personally saw a good deal of the war first-hand, from the viewpoint of the people who had to get the supplies with which to carry it on, and I really doubt if we could have won the war in the time in which we did if we had not had the fluorescent lamp—we just would not have had enough electric energy to get the 50, 60, 100 foot-candles and more which we had in our war plants, and with the comfort the new lighting provided, and at its high efficiency. (Incidentally, Germany did not use fluorescent lighting to any great extent in their war plants.)

After the war, development proceeded—we were able to follow up the planning which had been done in the war.

STARTING

We had had instant-start arrangements before the war, but with them the lamp life was cut about in half. Now, a brand new cathode gives us a real instant-start lamp, and they have been widely used. I want to point out, though, that in the 40-watt size for example, with instant starting, the ballast is heavier, and larger, because of the considerably higher voltage needed. The ballast is about twice as heavy, costs about twice as much, and has about twice the wattage loss. So, over-all, it costs a little more to use instant-start lamps, but nevertheless people have been using them in increasing numbers.

The watchdog type of starter, meanwhile, had solved the bothersome matter of blinking lamps—its use multiplies starter life many times.

With the development of longer lamps, such as the 8-foot slimline lamps, the voltage for instant starting is but little more than that required to have a sufficient margin for ballasting; so it adds very little to the cost to have instant starting. Hence slimline lamps are all instant starting.

As a matter of fact, the ratio of ballast open-circuit voltage to lamp-operating voltage should be about two to one to assure good regulation. With the 8-foot slimline, instant starting is obtained by increasing that ratio to about $2^1/_2$ to 1; to instant-start 40-watt lamps, the ratio has to be increased to $4^1/_2$ to 1. Hence, there is an increased cost for instant starting with the 40-watt lamps.

COLD CATHODE

Meanwhile, fluorescent-coated tubing, called "cold cathode," was being applied in relatively long lengths for general lighting, by the sign companies. There certainly has been entirely too much mystery and misunderstanding about this question of the difference between hot- and cold-cathode lamps. To the laymen among the readers, I can confuse you more thoroughly by mentioning that the lamp with the cold cathode actually feels hotter at the ends than the lamp with the hot cathode. Actually, it is a simple matter. The cold cathode does not emit electrons as readily; hence there is more voltage loss at the cathode (or more wattage loss at the cathode). The hot-cathode lamp has a cathode especially designed to give off electrons readily; hence there is less voltage (and wattage) loss at the cathode. Between the ends, the two lamps behave the same.

As a result, the hot-cathode lamp is some 25 per cent more efficient. But the cold-cathode lamp can be turned off and on repeatedly, or flashed, without affecting its life. Also, the cold-cathode lamp can be made to give a longer life. This is not always quite the advantage that it seems, though, because all fluorescent lamps keep on getting dimmer and dimmer as they get older, and after a while the user just cannot afford to keep them going, because of the very low light output. But the long life of the cold-cathode lamp makes it advantageous to use in places where the cost of renewing a lamp is very high, such as in a very high, inaccessible cove. Here, long life well may be the paramount factor.

LAMP SIZES

General Electric's development of fluorescent lamps is following four general lines:

1. Small or miniature sizes—where space is the predominating factor.
2. Intermediate sizes—the usual varieties for general lighting services.
3. Long sizes—that is, long, compared with lighting sources in general use.
4. Shaped varieties—be they circles, arcs, curves, or what not.

As far as General Electric lamps are concerned, these particular lines were determined on and announced at as early a date as possible—during the war, as a matter of fact, even at a time when the company could not go ahead on production. However, the announcements gave the fixture manufacturers an opportunity to plan ahead.

There since has been a great array of new lamps, which fall into one or another of these classes, and there undoubtedly will be more as time goes on. The lively competitive situation is likely to mean numbers of special lamps, each planned to have some particular advantage or another, even though, all things considered, it may not be at all the best for the service.

Let us consider some of the lamps of today.

LARGER LAMPS—KRYPTON

The 100-watt size was developed, just in time to be used in many war plants. It gave more light in a single package.

Then, in 1948, the use of krypton gas was announced. A paper by Found and Winninghoff at the Illuminating Engineering Society Convention in Boston in the fall of 1948 gave the facts regarding its use. In brief, it causes the lamp to run cooler—important with some lamps which were already close to the line as far as overloading is concerned, and which have been likely to overheat (with consequent reduction in light output) when placed in fixtures that cause them to run too hot.

Krypton reduces the voltage (and increases the current). Thus, with krypton, a lamp which would just barely require a step-up transformer might be operated on a 110-volt circuit, thus needing a less costly choke to run it. Or a lamp which would run on an 110-volt circuit could be made longer and still operate directly on the 110-volt line with a simple choke. Krypton, however, makes the lamp harder to start, a fact that perhaps has been overlooked by some. In addition, krypton gas is extremely rare—the supply is limited with the present facilities for extracting it from the air—and it is costly, even if additional facilities were available.

The first use of krypton in fluorescent lamps was on the 100-watt size, which already was loaded quite heavily. Now, the same light output could be obtained with only 85 watts in the lamp. This development came along just in time to aid in the programs of energy curtailment. You well might ask, "Why did you not keep the lamp at 100 watts and thus give the user more light? He usually needs more light." The answer is that it would have meant a different ballast, and thus the lamps could not have been used in the tens of thousands of sockets now in service. And if we were to design for 100 watts, there would be losses due to heating and other factors which would reduce the net gain to about 3 per cent.

LOW-BRIGHTNESS LAMPS

To get the maximum efficiency from a fluorescent lighting system—as many lamps are used today—the work (on the desk or table or machine) has been subjected to the unreduced brightness of the fluorescent lamps. Hence, there are specular reflections of the lamps themselves in shiny surfaces. At the higher illuminations, 100 foot-candles or so, these reflections are largely "drowned out" and usually cause no difficulty. At very low illuminations, say ten foot-candles, these reflections may be very disturbing.

To meet this problem, a low-brightness lamp has been made available—in effect, a 40-watt lamp in the larger (5-foot) tube of the 100-watt lamp. Lamp brightness is reduced to half that of a regular 40-watt lamp. This considerably improves the quality of the lighting installation. In fact, in offices, for example, some of the best-lighted ones I have seen are those of the Central Hudson Gas and Electric Company at Hudson and Newburgh, N. Y., or the First National Bank in Chicago, Ill., which use these low-brightness lamps.

SHAPES

In December 1943, the General Electric Company announced its intention of making three sizes of circline fluorescent lamps: the 8-inch; the 12-inch; and the 16-inch. The development of the necessary machinery to produce them has been proceeding. The middle size is now available; the demand seems to be in the millions, with its popularity controlled only by availability. There is a small production of the smallest size; shipments are limited to one particular field of use, pending larger production facilities. The largest size still appears to be some time off, pending the development and building of the necessary machinery to make them.

There have been many other variations of shapes suggested. One manufacturer has made a half circle, about the same as cutting this middle size in half.

LOW-TEMPERATURE OPERATION

Low-temperature operation has come in for attention, as more and more people use the lamps outdoors and in unheated buildings. Fluorescent lamps are difficult to start in very cold weather, and so a special low-temperature lamp has been made available. Most users, though, seem to get by with the ordinary lamps, even though they are not warranted to start in cold weather. It should be remembered also that the light output falls off in cold weather (Figure 2), which sometimes means jacketing the lamp to keep it warm. Since the light output also falls off if the lamp gets too hot, you may have to take off the jacket in hot weather.

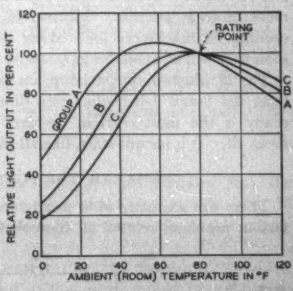

Figure 2. Fluorescent lamps give maximum light output at a certain ambient temperature; note falling off in temperature if they are too hot or too cold

Group A—lamps relatively overloaded
Group B—lamps normal in current density
Group C—lamps relatively underloaded

HIGH-HUMIDITY OPERATION

High humidity sometimes causes trouble in starting and so a stripe or a silicone coating has been used to improve

starting under high-humidity conditions, such as in a cotton mill.

COLOR OF THE LIGHT

This factor always seems to excite interest. Today we have five different so-called "white" lamps:

1. Improved soft white—a new color designed to make people' and many things, look better.
2. Warm tint—closest to filament.
3. 3,500 degrees Kelvin, white.
4. 4,500 degrees Kelvin, white—cool and fresh.
5. Daylight, 6,500 degrees Kelvin.

It is of interest to note that about two-thirds of the demand is for 3,500 degrees and 4,500 degrees white and one-fifth of the demand is for daylight, leaving warm-tint and soft-white a small proportion.

An interesting special color is the photocolor lamp, made for viewing colored film and transparencies. It has extra red phosphor added to bring out the reds more strongly. You might ask, "Why not use it for general lighting?" It would be good in many places where the extra red would warm things up a bit, but the efficiency is reduced materially, and most people, for general lighting, will not afford this loss, which adds to the cost of the light.

Also to be considered are the so-called "Black Light" fluorescent lamps. These lamps have a special phosphor rich in radiation at 3,600 angstroms which is just the right wave length to excite the ordinary fluorescent materials, dyes, paints, and so on that are used for black light effects, and for the numerous industrial applications of black light, such as laundry marking.

One of the newest fluorescent lamps is what might be called a larger version of the 8-foot slimline lamp. It is an 8-foot *T-12;* $1^1/_2$-inch-diameter lamp which first was shown by the General Electric Company at a meeting of fixture manufacturers at Nela Park in 1947 as a development of great promise. Meanwhile, work has been proceeding on machinery for making these long lamps, and soon they will be available in quantity.

The $1^1/_2$-inch-diameter lamp has an even higher output than the 8-foot 1-inch-diameter slimline lamp which already is the most efficient "white" fluorescent lamp of them all. It is instant-start, like all slimline lamps.

WHAT OF THE FUTURE?

There are so many able people working on the multifarious problems related to fluorescent lamps and lighting that there are certain to be many new developments within the next few years.

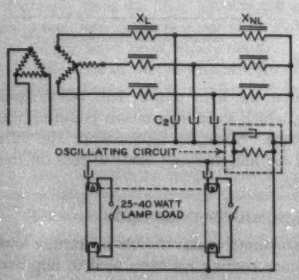

Figure 3. The basic circuit of a magnetic frequency converter which is supplied with a 60-cycle 3-phase current and delivers 540-cycle current in sufficient amount to light 25 40-watt fluorescent lamps

New circuits show much promise. For example, there was the system of operating four 100-watt fluorescent lamps on a sequence circuit from a 265-volt load center system, which reduced the cost of lighting in plants where this voltage was available. Now, work is being done on a somewhat similar arrangement for four of the 85-watt lamps on the more popular 238- and 208-volt systems.

Consider the use of higher frequencies for operating fluorescent lamps.[1,2] When operating on higher frequencies, say 400 or 540 cycles, the size of the ballast shrinks to an almost irreducible minimum—the use of capacitor rather than reactor ballasts becomes practicable—and the efficiency of the lamps, and, even more important, the over-all efficiency of the system, is increased by as much as 20 per cent with 40-watt lamps.

The problem is getting the 400 or 540 cycles simply and inexpensively. Certainly, the equipment for doing so should not be more costly than the net saving in the ballasts. And it should be of a size suitable for use in lighting load distribution centers or panel box locations, for it appears quite practicable to carry frequencies of these magnitudes through the secondary distribution system of an individual building.

Preferably, the conversion system should have no moving parts (Figure 3). Already, experimental arrangements meeting these requirements, except in the matter of cost, have been produced by General Electric's General Engineering and Consulting Laboratory at Schenectady, N. Y., and the outlook is bright.

There are many other phases of fluorescent lamps and their operation that are being worked on actively. Up to now the basic methods of controlling the lamps have changed but little since that memorable occasion when the fluorescent lamp was announced nearly 11 years ago. But for the future, if I were to assume the role of a prophet, I would predict: Higher efficiencies—new methods of starting and of operation—lamps operated at higher light outputs (more light in the package)—lower costs for control equipment—lower costs of fixtures and greatly improved candlepower maintenance of the lamps—and lower costs for fixture installation—in short, lower over-all costs of light so that users can get the better lighting that they are now beginning to appreciate that they need.

We have a long way to go. It is almost 30 years since I first started in the lighting business. In that time, I have seen the efficiencies of light sources increased three times, thanks largely to the fluorescent lamps which we have been discussing. Are we nearing saturation? Well, to answer this, it is only necessary to remind the reader that the fluorescent lamps of 1949 have reached only about one-third of the maximum theoretical efficiency for the production of white light. What other commonly-used electric device can match its possibilities for future development?

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The Thermal Movement of Moisture in Soil

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ASSOCIATE AIEE

IT HAS long been known that when a moist soil is subjected to a temperature gradient, the moisture will have a tendency to move in the direction of heat flow. This phenomenon is of considerable interest in cable heating studies because the thermal conductivity of the earth in the heat field involved will decrease as moisture is lost. It is of like interest in the heat pump using a buried ground coil, where migration has also been observed.

The moisture in the soil is considered to be held in droplets between soil particles. The application of a thermal gradient causes these droplets to move from the warmer to the cooler regions. Such movement apparently takes place almost entirely in the liquid phase, and not in the vapor phase, as might at first be supposed. The hypothesis is advanced that the thermal gradient causes the individual droplet to distort in shape due to the thermal coefficient present in the value of surface tension. In the process of distorting, the droplet may meet another droplet and the two merge into a single larger droplet. This new droplet will have a tendency to move to the cooler region in the search for a condition of surface tension equilibrium among the complicated crevice system presented by the soil particles. The mathematical expression for this process is on a probability basis, and includes two factors:

1. Amount of distortion, which is proportional to temperature gradient.

2. The probability of meeting another droplet for a given distortion, which is proportional to the difference of the second and fifth powers of moisture content.

$$\Delta M = k\frac{dT}{dx}\left[\left(\frac{M_i}{F}\right)^2 - \left(\frac{M_i}{F}\right)^5\right] \qquad (1)$$

is the complete equation, where

ΔM = Moisture lost
k = Constant, depending on soil type
dT/dx = Temperature gradient
M_i = Initial moisture content
F = Saturation moisture content

A typical relationship for one soil sample is given in Figure 1. From this it can be seen that the migration is highest at about 75 per cent of saturation.

Electrical utilities, with large investments in underground cables, for many years have feared the effects of moisture migration on cable temperatures. In the absence of a means to evaluate this effect, they have limited the temperature of cables and ducts in direct contact with the earth, in the hope that a serious runaway of moisture would be prevented. This temperature limit is usually set at 50 to 55 degrees centigrade.

Digest of paper 49-83, "The Thermal Movement of Moisture in Soil," recommended by the AIEE Insulated Conductor Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31–February 4, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Table I. Examples of Moisture Movement Effects

	6-Cable Duct Bank	8-Inch Pipe
Maximum heat flow, watts per foot	30	38
Buried depth to center, inches	43	40
Initial earth resistivity, degrees centigrade centimeters per watt	75	60
Maximum temperature gradient, degrees centigrade per centimeter	0.45	1.17
Temperature rise of structure, degrees centigrade		
(a). Neglecting moisture movement	25.2	35.7
(b). With maximum moisture movement	26.0	37.5
(c). Per cent increase due to moisture movement	3.2	5.0

Equation 1 has been applied to the heat field of a buried cylinder for the purpose of providing a method to determine the effect of moisture movement on actual cable problems. The application of the method to two typical examples is given in Table I. Solution of a typical problem of a high-tension pipe-type cable system indicates that the temperature rise of the pipe would change only from 36 to 38 degrees centigrade with the most unfavorable migration conditions.

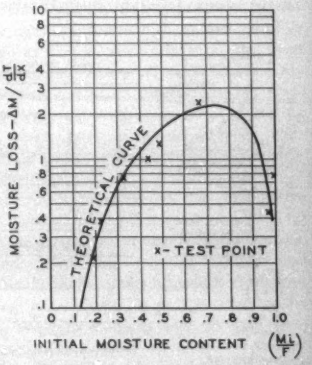

Figure 1. Thermal movement of soil moisture — theoretical curve of surface tension movement plotted against experimental data for Barnes loam, substratum soil level

Experimental data are from W. O. Smith's paper, "Thermal Conductivities in Moist Soils," Proceedings, Soil Science Society of America, 1939

One should not expect that the moisture movement phenomenon discussed in this paper would be applicable at very high temperature gradients. Little is known about the critical temperature gradient, beyond which moisture will migrate until only dry earth remains. The author has had but one experience with this drying-out effect. In this instance the drying-out effect started at 65 degrees centigrade and at a surface temperature gradient of 6.6 degrees centigrade per centimeter, but proceeded in an orderly fashion, with the effective earth resistivity stabilizing at a new level approximately 30 per cent greater than the original one.

Frequency-Response Control Charts

A. B. MUNDEL
MEMBER AIEE

CONTROL chart methods[1] developed extensively in connection with mechanical tolerances are useful in controlling the frequency-response characteristics of electro-acoustic receivers. The entire frequency response of a receiver can be kept within statistical control by controlling the critical regions alone. Two of these critical regions are described.

One critical region occurs at low frequencies where the acoustic output is a function of the efficiency of the magnetic system and the combined stiffness of the diaphragm and the acoustic chambers surrounding it. A control chart is plotted by taking a sample of five receivers from the production process at regular intervals of time and measuring their acoustic response. The average response of the five receivers at 400 cycles and the range are plotted in Figure 1 (the range is the difference between the maximum and the minimum responses in each example of five). Figure 1 shows a control chart in which 19 samples of five have been

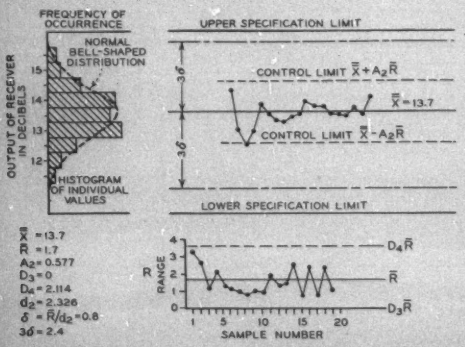

Figure 1. Histogram and control chart of receiver response at 400 cycles per second; response of five receivers plotted

taken and the average $\bar{X}$ and range R plotted. The grand average $\bar{\bar{X}}$ and the average range $\bar{R}$ also have been indicated in the diagram.

Control limits for the averages and ranges are indicated by the dotted lines. The points on the graph of Figure 1 all should lie within the indicated control limits if the process represented approximates a symmetrical bell-shaped frequency distribution as shown at the left of Figure 1. If all points do not lie within control limits there is evidence of

Digest of paper 49-109, "Control Chart Methods Applied to Frequency Response Curves," recommended by the AIEE Communication Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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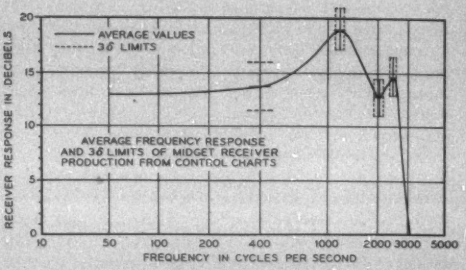
AVERAGE VALUES
3σ LIMITS
AVERAGE FREQUENCY RESPONSE AND 3σ LIMITS OF MIDGET RECEIVER PRODUCTION FROM CONTROL CHARTS
RECEIVER RESPONSE IN DECIBELS
FREQUENCY IN CYCLES PER SECOND

Figure 2. Curve showing 3σ (three sigma) limits of response, indicated by dotted lines, of miniature receivers in production

variations due to assignable causes rather than to pure chance. A point outside of the control limits indicates that at least one controlling factor has changed. When a control chart is maintained on a production process, it is important that the reasons for the changes (out of control points) be found and corrective action taken to adjust the manufacturing process. Otherwise, changes are developing in the product. From an engineering analysis of the operation of the receiver we know that a point outside of the control limits at 400 cycles indicates that a change has occurred in the magnetic circuit, the air gap, or the net stiffness of the system. Each of these parameters can be individually checked and an adjustment made so as to obtain again the proper responses. Individual values of the 400-cycle receiver response are shown in the form of a histogram at the left of the control chart of Figure 1.

Control charts are kept at other critical frequencies and amplitudes. The chart not only shows whether control exists but indicates what corrective action is appropriate. At the first resonance, for example, a control chart is kept on the amplitude of the responses. If the average response is out of control on the high side, the acoustic damping should be increased. If too low, the acoustic damping should be reduced.

Control chart data provide an excellent basis for obtaining average values of response curves and probable limits for individual units. The three sigma (3σ) limits for individuals, shown by the dotted line limits on the response curve of Figure 2 would include 99.7 per cent of the product if the product is normal and in continuous control. Similar quality control techniques by statistical methods are useful in analyzing problems arising in the manufacture and development of transducers and similar devices.

REFERENCE

1. A.S.T.M. Manual on the Presentation of Data. The American Society for Testing Materials (Philadelphia, Pa.), March 1941.

Thoriated Tungsten Filaments in Rectifiers

Z. J. ATLEE

THORIATED tungsten filaments have been in widespread use for low-voltage tubes for many years. By the addition of the carbonization process, they are used successfully at several thousand volts. The generally accepted view as expressed in textbooks and papers as recently as 1941 has been that 5,000 volts was the maximum voltage for a thoriated tungsten filament. Today, it is well known that during World War II the demands of radar and other electronic equipment raised the ceiling for thoriated carbonized tungsten filaments to 35,000 volts.

Having reached this voltage range of operation, the next logical step to the 100-kv range required by the rectifiers used in the diagnostic X-ray application did not look impossible. In 1947, the Dunlee Corporation undertook the development of a very small tube primarily intended for the X-ray diagnostic application which would require a maximum of 110 kv and 250 milliamperes from a full-wave bridge rectifier with four rectifier tubes. The tube valve developed, as illustrated in Figure 1, is less than six inches long and has a 25-watt thoriated tungsten filament in place of the 125 watts required by the pure tungsten filament valves now used in the X-ray industry.

With lower work function, an emitter of thorium on tungsten as provided by a thoriated tungsten filament gives a much greater electron emission at a lower operating temperature range of 1,800 to 2,200 degrees Kelvin as compared to the 2,200- to 2,600-degree Kelvin range for pure tungsten. Expressing the efficiency of emission in milliamperes per watt, 30 to 40 milliamperes per watt can be obtained with a life of 2,000 hours from a thoriated tungsten filament. In comparison, a pure tungsten filament is limited to ten milliamperes per watt, even with as little as 250 hours' life. For 1,000 hours' life, only five milliamperes per watt are obtainable. At five milliamperes per watt, the thoriated tungsten filament has a life potential in excess of 50,000 hours.

From experience with lower-voltage tubes with thoriated tungsten filaments, such as the *6C21* tube developed for operation up to 35,000 volts, it seemed that only three specific problems had to be answered in determining if an X-ray valve could be made to use successfully such a filament. Would it be possible to maintain emission? Would it be possible to maintain rectification? That is, would the tube function as a high-voltage rectifier, or would the introduction of the thoriated filaments with apparent dangers of thorium deposits cause inverse breakdown? Would a tube with a carbonized filament be mechanically rugged enough for use in the X-ray industry?

Digest of paper 49-88, "High-Voltage Rectifier Tubes With Thoriated Tungsten Filaments," recommended by the AIEE Electronics Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 31-February 4, 1949. Not scheduled for publication in AIEE *Transactions*.

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Figure 1. An oil-immersed valve with 25-watt thoriated tungsten filament for 110-kv operation

By the use of ample getter incorporated in a new and extremely simple fashion, loss of emission by positive ion bombardment is prevented. This also partially protects the anode against unwanted thorium deposits which spoils rectification. The major difficulty encountered in the development was that of preventing thorium deposits on anode and glass, caused by "cold cathode" breakdown during the seasoning required to give stable high-voltage operation with the limited electrode clearances required in a small tube. This difficulty has been solved by the development of a new process which makes possible seasoning at as high as 150 kv after the tube has been permanently evacuated, and before carbonization and activation of the filaments has taken place. In this manner, the tube can be seasoned without danger of sputtering thorium deposits, which later on would prevent high-voltage rectification or cause partial breakdown as indicated by surging.

With the characteristics provided by the small valve developed, certain very desirable features in addition to that of size are made available for the X-ray diagnostic rectifier application. With the trend to smaller and smaller units housing the high-voltage transformer, the four valves, their filament transformers, as well as those for the X-ray tubes, the 500-watt filament heat of four pure tungsten valves has limited the duty cycle as well as size. With only 100 watts required for four of these valves, this limitation is removed, and with further improvements in insulation, and so on, even smaller units are possible. Another advantage is that the filament transformer can be smaller and identical to those required by the X-ray tubes, thus making standardization possible. Boosters, stabilizers, or compensation windings are not essential to insure against emission-limited operation from the valves due to poor line-voltage conditions, in that excess emission is available.

Although these valves were developed for the X-ray diagnostic application, their characteristics suggest their application for other X-ray generators, such as therapy and crystallography. In other fields using similar or even identical construction of valves, the more efficient cathode with longer potential life should make this new type of valve attractive. These valves should prove ideal for very-high-voltage television rectifiers.

Recloser-Fuse Co-ordination

G. G. AUER ASSOCIATE AIEE R. A BRANFLICK ASSOCIATE AIEE L. J. WOODWARD ASSOCIATE AIEE W. C. McKINLEY

DEPENDABLE electrical service in suburban and rural areas is of increasing importance because of the addition of many new electric appliances to the home and the continued expansion of farm electrification. Power outages seriously inconvenience the residential consumer and may cause heavy loss of produce on the farm. Moreover, rising labor and automotive costs have increased utility operating expenses to a point where an excessive number of service trips no longer can be tolerated. It is, therefore, of vital importance that overcurrent protection for suburban and rural circuits be properly applied to yield the greatest reduction in the number and extent of outages.

In recent years, much emphasis has been placed on the application of automatic reclosers and distribution fuse cutouts for overcurrent protection of suburban and rural distribution circuits. In order to yield the greatest possible reduction in the number and extent of outages, it is of vital importance that this equipment be properly co-ordinated. Following are the considerations which form the basis for an analytical method used to determine the co-ordination of reclosers with series fuses.

The primary function of any recloser in a distribution circuit is to clear, by instantaneous opening, all possible temporary faults before fuses blow, and, by time-delay opening, to provide for clearing all permanent faults occurring in its zone of protection. A recloser, in order to accomplish this function, must have reliable characteristics capable of providing proper recloser-fuse co-ordination irrespective of ambient temperature changes and of providing co-ordination with adjacent ratings of reclosers in series.

It is realized that with a recloser and a fuse in series with a fault, each operation of the recloser will cause alternate heating and cooling of the fuse. Consequently, the total heat input required to melt the fuse cannot be determined directly from the published melting-time–current characteristic curve of the fuse. In addition to effective heating and cooling of the fuse, the manufacturing and operating variables of each device also must be properly evaluated.

In co-ordinating reclosers and fuses, proper allowances must be included therefore for each of the following factors:

1. Total variations in recloser tripping characteristics.
2. Total heat input to the fuse during the time required for the recloser to open and interrupt the fault current.
3. A reduction of 25 per cent in melting-time–current characteristics of the fuse to factor operating variables such as preloading and to avoid melting of the fusible element without melting the strain wire.
4. Cooling of fuse during intervals that the recloser is open.

An analytical co-ordination method, based on the foregoing considerations, was substantiated by a series of field tests performed on a typical rural distribution circuit located on the Central Electric Cooperative system at Parkers Landing, Pa. The circuit selected for these tests was a 7,200-volt single-phase branch line approximately 25 miles long with three sectionalizing points. The ratings of reclosers were selected on the basis of fault current and load current, resulting in a 25-ampere recloser at the first location, a 15-ampere recloser at the second location, and a 10-ampere recloser at the third location. The ratings of the fuses used for these tests were selected on the basis of the procedure previously outlined. Oscillographic equipment was used to record the test results.

In testing recloser-fuse co-ordination, the first series of tests showed the effect of accumulative fuse heating during successive operations of the recloser. Comparing the actual fuse clearing time recorded on the oscillogram with the standard published total-clearing-time–current characteristic of the fuse, the fuse cleared the circuit appreciably faster as a result of accumulative heating during successive recloser operations, as was expected.

The second series of tests showed the effect of alternate heating and cooling on the operation of the fuse. Oscillographic records of the actual fuse clearing time compared very closely with the results obtained by the analytical co-ordination method for calculating the effective heating and cooling of the fuse.

In testing recloser-to-recloser co-ordination, it was found that where reclosers have an operating sequence which involves both instantaneous and time-delay operations, two or more reclosers having overlapping zones of protection may operate instantaneously before the smallest rating adjacent to the permanent fault operates twice on time-delay and locks open. This is inherent in all types of reclosers which operate instantaneously and arises from the fact that the instantaneous openings of the larger ratings may be faster than the time-delay openings of the smallest rating. An analysis of the oscillograms for this part of the test showed that co-ordination is not affected, because the smallest rating always will lock open and permit the larger ratings to reset automatically to normal position. Reclosers in adjacent sections opened either simultaneously or consecutively, and after each had completed its two instantaneous openings, only the smallest rating of recloser operated twice more on its time-delay characteristic to lock open.

The field tests also disclosed that motor inrush currents on line sections between reclosers may affect the sequence of instantaneous operations of the reclosers.

Digest of paper 49-128, "Field Tests of Oil Circuit Recloser Substantiate Analytical Co-ordination Method," recommended by the AIEE Committee on Switchgear and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20–24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Semiconductor Rectifiers

A summary of the material on rectification presented at a symposium held during the recent AIEE Summer General Meeting, this article discusses qualitatively the theories of rectification and noise generation in metal-semiconductor contacts.

FOR OVER a century it has been known that the contact between a metal and a semiconductor can result in a resistance which is a nonlinear function of the voltage applied. The earliest embodiment of this discovery to find practical application was the well-known "cat whisker" crystal detector which was used in the early days of radio to rectify high-frequency alternating currents. The discovery of the vacuum tube triode made the crystal detector rapidly obsolete, because the vagarious sensitivity of the crystal could not compete with the more stable and controllable sensitivity of the vacuum tube.

With the discovery of the selenium rectifier by Fritts in 1883 and the cuprous oxide rectifier by L. O. Grondahl in 1926, the semiconductor rectifier launched into a new field—high-power low-frequency rectification. These rectifiers contrast with the crystal detector by the large area contact between the metal and semiconductor. Although the selenium rectifier preceded the cuprous oxide disk, the latter was developed first into a practical industrial component. Recently, selenium rectifiers have developed to the stage where one has a choice of the type of rectifier to use on the basis of the kind of service needed. There have been other types of large area rectifiers built, but the only survivor in addition to the two referred to is the copper sulphide rectifier. This is used primarily for low-voltage high-current duty.

The progression of radar to higher and higher frequencies during World War II soon disclosed that the conventional vacuum tube was inadequate as a detector or a superheterodyne mixer. The crystal detector with negligible transit time and low capacitive reactance found immediate application. Research and development soon removed the major objections to the old cat whisker detector, and produced in quantity a stable, cartridge-type component which evidently will not suffer sudden obsolescence. Continued interest in semiconductor rectifiers is perhaps insured by the development of detectors able to sustain high reverse voltages. This discovery has made available compact diodes with which the thermionic diode can scarcely compete. The recent announcement that a second probe placed near to the rectifying junction of a germanium diode can influence the current by the transistor effect, has provided a semiconductor triode which will be a competitor for vacuum tubes in some applications. It is not generally believed that the historical order of obsolescence will now be reversed, but that transistors will stimulate new applications suited to the unique properties of this device.

Many different theories have been proposed from time to time during the long history of semiconductor rectifiers to explain the voltage dependent contact resistance. Significant progress was possible only after A. H. Wilson's application of the band theory of the solid state to semiconductors. Independently and at nearly the same time, N. F. Mott and W. Schottky proposed theories based on the new concepts. These theories were intended for the large area rectifier, but modifications were quickly supplied when the point contact rectifier became important.

This article will summarize the material on rectification presented at a symposium during the AIEE Summer General Meeting giving a qualitative discussion of the theories of rectification and noise generation in metal-semiconductor contacts.

RECTIFIER THEORY

The diagrams which depict the energy states allowed to an electron in a metal and a semiconductor will be discussed in detail in a subsequent issue.* It is logical that this discussion of the contact should be based upon a model which is the adjunction of the two diagrams for the bulk materials.

Figure 1 shows the energy level diagrams of the metal and the semiconductor widely separated so that the reference level for energy is that of an electron at rest distant from both bodies. Immediately following contact of the metal and semiconductor, higher energy electrons will flow across the contact to fill lower levels until an equilibrium condition is reached, which means that there is a

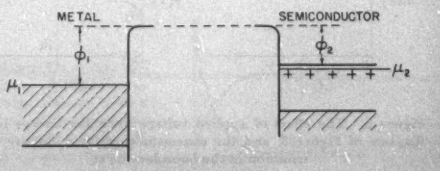


Figure 1. Energy level diagrams for a metal and an n-type semiconductor

A compilation based upon the following four papers presented at section *C* of the Symposium on Electrical Properties of Semiconductors and the Transistor held during the AIEE Summer General Meeting in Swampscott, Mass., June 20-24, 1949: "Theory of Rectification," **Frederick Seitz** (A '37), Carnegie Institute of Technology, Pittsburgh, Pa., and session chairman; "Boundary Layers in Rectifiers," **H. Y. Fan**, Purdue University, Lafayette, Ind.; "Noise in Semiconducting Contacts," **P. H. Miller, Jr.**, University of Pennsylvania, Philadelphia, Pa.; "A Comparison Between the Schottky Rectifier Theory and Measurements Upon Cuprous Oxide Cells," **S. J. Angello** (A '42), Westinghouse Research Laboratories, East Pittsburgh, Pa. The compilation was prepared by **S. J. Angello.**

* A compilation by K. Lark-Horovitz of three papers presented during section *A* of the Swampscott symposium, which dealt with the nature of conductivity in semiconductors, is scheduled for publication in an early issue of *Electrical Engineering*.

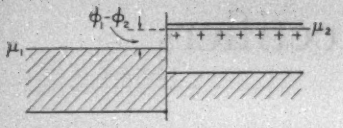


Figure 2 (left). A metal and an n-type semiconductor in contact but in a nonequilibrium condition

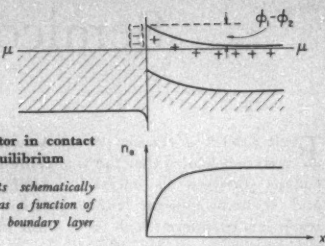


Figure 3 (right). A metal and an n-type semiconductor in contact and in equilibrium

Lower curve depicts schematically the electron density as a function of distance through the boundary layer

detailed balance of energy flowing across the contact in either direction. The criterion used in the diagram to show the equilibrium condition is the matching of Fermi levels, μ. Figure 2 illustrates the nonequilibrium condition after contact in which the thermodynamic potentials per electron, or Fermi levels, μ_1 and μ_2 are not coincident. It is shown in thermodynamics[1] that a system in this condition will do nonmechanical work until the levels match as pictured in Figure 3. The nonmechanical work in this case is the electrical work necessary to establish a contact difference of potential $\varphi_1-\varphi_2$ with a concomitant space charge. Figure 1 illustrates a special case because the work function of the metal (φ_1) was chosen larger than that of the semiconductor (φ_2) and the semiconductor is *n*-type.

The formation of a positive space charge in the *n*-type semiconductor in the region of the contact depletes this region of electrons which appear as a surface charge on the metal. A schematic plot of the electron density in the boundary region as a function of the distance from the metal is shown in the lower part of Figure 3. The depletion region which has been called the "natural blocking layer"[2] is between 10^{-4} and 10^{-6} centimeter thick, depending upon electrical properties of the materials. A qualitative notion of how the contact yields an asymmetric resistance as a function of applied voltage can be gained by Figure 4, which shows on the left a negative voltage applied to the semiconductor to raise the Fermi level above that of the metal, and on the right the reverse. In the first instance electrons have a smaller potential barrier to hurdle than in the latter instance. In the limiting condition, negative potential on the semiconductor wipes out the contact space charge, and current flows only impeded by the bulk resistance of the semiconductor. This is the forward or low-resistance direction of the rectifier. Positive potential on the semiconductor is the blocking or high-resistance direction, because electrons must hurdle the full potential step $\varphi_1-\varphi_2$.

When one considers a quantitative theoretical description of this model two alternatives arise immediately. These concern whether or not the natural blocking layer is thin compared with the electron mean free path in the semiconductor. If it is thin, then collisions of electrons with the crystal structure in the blocking layer need not be considered, and the configuration is analogous to a vacuum diode in which the cathode is the semiconductor and the anode is the metal. This type of diode theory[3] has been applied to silicon and germanium point contact rectifiers. The conditions in the blocking layer of selenium and cuprous oxide rectifiers favor a diffusion type of theory in which electron collisions with the crystal structure of the blocking layer must be considered.

The adjunction of a metal with an *n*-type semiconductor need not result in the formation of a natural blocking layer. Figure 5 illustrates the situation if the metal work function (φ_1) is smaller than the semiconductor work function (φ_2). The potential step is now inverted so that there is no impediment to electrons in the conduction band. Such a contact will obey Ohm's law. The two remaining cases are shown in Figure 6*A* and *B*. Figure 6*A* is a *p*-type semiconductor in contact with a metal with a work function (φ_1) less than the semiconductor (φ_2). It can be seen that the potential is such to give rise to an asymmetric resistance-voltage characteristic, if one now concentrates attention on the holes which move at the top of the full band. Application of positive potential to the semiconductor lowers the Fermi level relative to that of the metal as before, but this time the step which holes must pass under is lessened. It is evident that this is the forward direction, and that

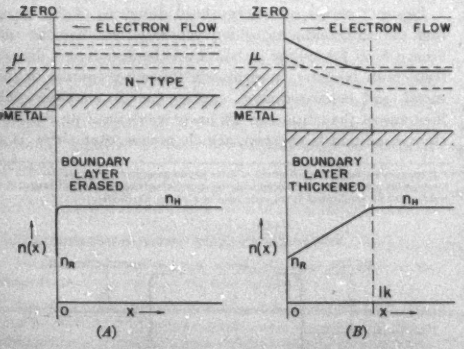


Figure 4. The effect of applied voltage upon the energy level diagram of Figure 3, and the concomitant electron density distribution in the boundary layer

A—Large forward applied voltage
B—Large reverse voltage applied

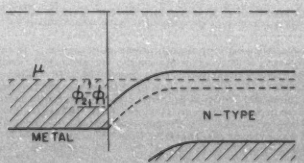


Figure 5. An n-type semiconductor in contact with a metal with a smaller work function

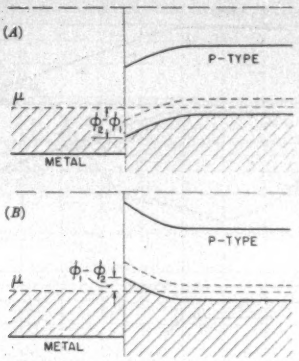


Figure 6. A p-type semiconductor in contact with a metal

A—With a smaller work function
B—With a larger work function

negative potential on the semiconductor will correspond to the blocking direction. Considerations analogous to those which have gone before will show that the final case, Figure 6*B*, corresponds to an ohmic contact.

The establishment of a natural blocking layer in the model which has been under discussion is dependent upon work function differences. In particular, the blocking layer in a given semiconductor should depend upon the metal in contact. There is evidence,[4] however, that the properties of germanium and silicon rectifiers are sometimes independent of the metal in contact. This has been explained by postulating[5] the existence of extra energy states on the surface of the semiconductor which produce a potential variation at the surface even when it is not in contact with a metal. Figure 7 illustrates the situation in the case of an *n*-type material. Changing the potential at the surface changes the position of the surface states relative to the Fermi level (μ); this in turn changes the degree to which these levels are occupied by electrons. If the density of surface states is high, a slight rise in the surface levels will result in a large decrease in charge. When a metal is brought into contact with such a surface, the necessary contact potential difference for equilibrium can be taken up in a small gap (perhaps as small as atomic dimensions) between the metal and the semiconductor surface. The blocking layer in the semiconductor is only slightly affected and explains the insensitivity of rectification to the metal in contact.

Experience with rectifier construction has revealed that the role of the natural blocking layer may be modified or superseded by an "artificial" blocking layer.[6,7] Artificial blocking layers may consist of a more or less abrupt change in the electrical properties of the semiconductor in the boundary region near the metal, such as a decrease in donator density; or the formation of a compound between the metal and semiconductor with different electrical properties; or the deliberate introduction of films of foreign materials such as lacquer, plastics, and evaporated layers of insulating compounds. Mott's pioneer theory[8] postulates a blocking layer of insulating cuprous oxide in the contact region of the cuprous oxide rectifier. Selenium rectifiers have been made with artificial blocking layers which are superior to those without deliberate inclusion. Figure 8 illustrates the potential and electron density distribution which may be found in such a contact. If the materials on the two sides of the barrier are different, the concentration of charge carriers in the barrier is different at the two boundaries. Under applied voltage, the concentration of charge carriers in the barrier becomes increasingly dependent on the value at the boundary from which charge carriers flow into the barrier. Other factors being constant, resistivity of the blocking layer is inversely proportional to the electron density within it; barrier resistance will depend on the direction of current flow.

Rectifying barriers may be found, not only at the contact between a metal and a semiconductor, but also within a single piece of semiconductor. If one part of the semiconductor is *n*-type and the other part *p*-type, then the concentrations of conduction electrons and holes in the boundary region are as sketched in Figure 9. Such a *p–n* boundary can be an efficient rectifier. These boundaries are found naturally in semiconductor melts, and they also can be produced artificially[9] in *n*-type germanium by subjecting one part to nuclear bombardment to convert it to *p*-type. When voltage is applied in such a direction that the *n* part is positive, electrons are driven from the *p* part where they are scarce into the *n* part. Conversely, holes are driven from the *n* part where they are scarce into the *p* part. The result is that the density of holes and electrons decreases in the barrier region causing an increase in resistance. This is the reverse or blocking direction. It is easy to see that reversing the sign of the applied

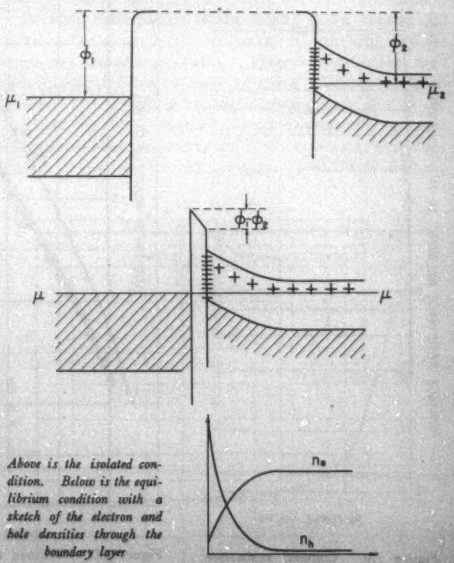

Above is the isolated condition. Below is the equilibrium condition with a sketch of the electron and hole densities through the boundary layer
n_e
n_h

Figure 7. The effect of surface energy states upon a metal-semiconductor contact

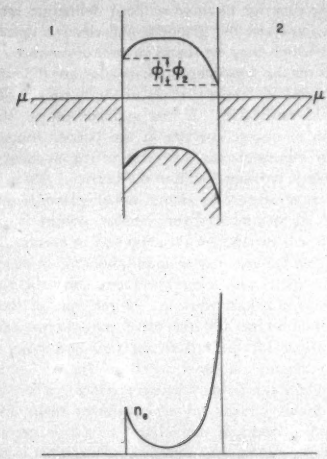


Figure 8. Potential and electron distributions through an artificial blocking layer

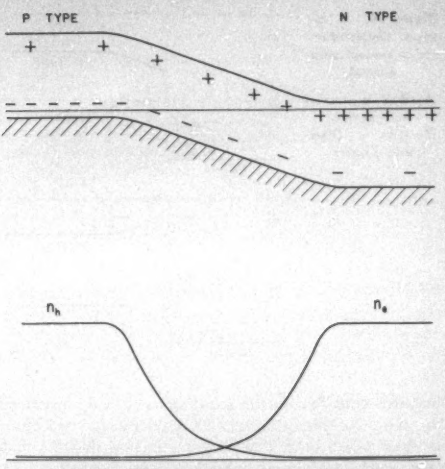


Figure 9. The energy level scheme for a p-n junction with the concomitant electron and hole density distributions

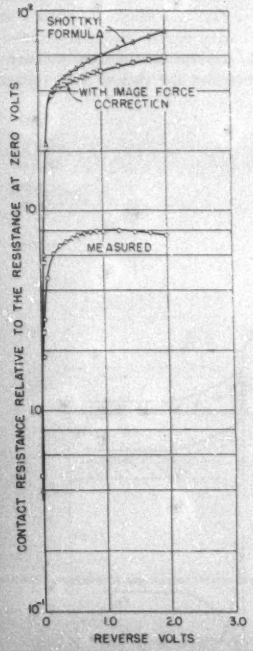


Figure 10. Contact resistance versus bias voltage plotted relative to the resistance at zero volts

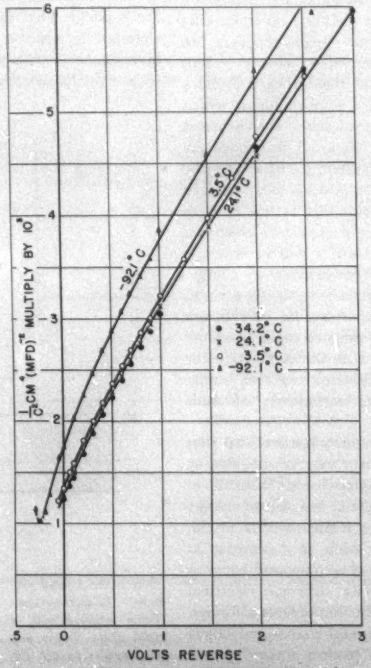


Figure 11. Elastance squared versus bias voltage for various temperatures

Copper-cuprous oxide rectifier ML14-2

voltage will reverse the trends enumerated and result in a lowering of the barrier resistance.

RECTIFIER THEORY AND EXPERIMENT

The Schottky theory[10] of rectification applied to the cuprous oxide rectifier is in an advanced stage of development. A numerical comparison between predicted and measured quantities will be given here to impart a notion of the magnitudes involved. Recently,[11] the diode theory has been advanced, but this was not discussed at the symposium.

A primary concern for rectifier theories is a discussion of the relation between contact resistance and direct voltage applied. By contact resistance is meant the resistance measured in an a-c impedance bridge with a small value of rms voltage applied (~5 millivolts). At a low frequency it is equivalent to the slope of the static current-voltage curve at the d-c bias voltage under consideration. Figure

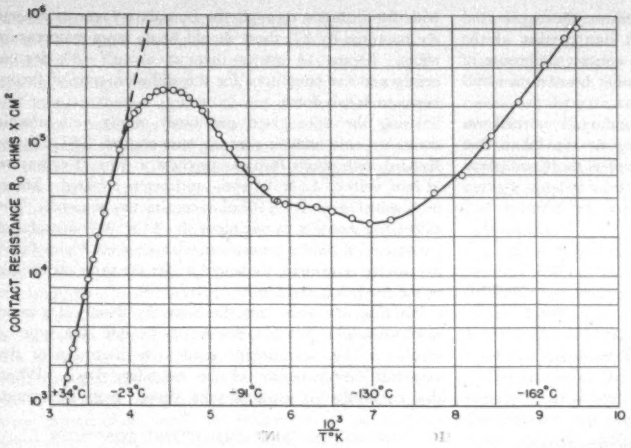


Figure 12. Contact resistance at zero bias versus reciprocal absolute temperature

Copper-cuprous oxide rectifier ML14-2

10 shows contact resistance as a function of bias voltage plotted relative to the resistance at zero volts. The reason for plotting this way is to compare only curve shapes. Predictions of absolute values of contact resistance will be discussed presently. The plot shows that the theory predicts the correct general shape, but the measured data fall about an order of magnitude below the parabolic portion of the calculated curve. This discrepancy and others to be noted are undoubtedly due to oversimplification in the model for the boundary layer structure.

The relation between contact capacitance and bias voltage is important. Schottky showed that the slope of the elastance squared versus voltage curve gives an estimate of the density of conduction centers in the semiconductor near the metal contact for natural blocking layers. Figure 11 illustrates the relation. The slope at zero volts yields 5.6×10^{15} centers per cubic centimeter. This number is one bit of data useful for computing the contact resistance.

Another consequence of the theory is an exponential relation between contact resistance at zero volts and reciprocal absolute temperature. Figure 12 shows how well this relation is followed down to about −10 degrees centigrade. The deviation at this temperature is due to the fact that the simple parallel resistance-capacitance equivalent circuit model is inadequate at the measuring frequency (1,000 cycles per second). Figure 13 indicates that re-

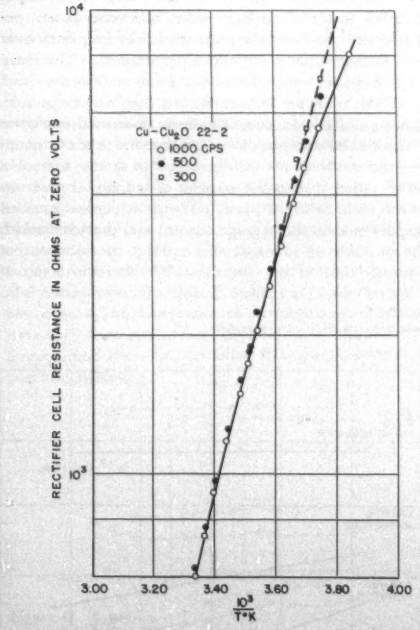


Figure 13 (above). Contact resistance at zero bias versus reciprocal absolute temperature for various measuring frequencies

Copper-cuprous oxide rectifier 22-2

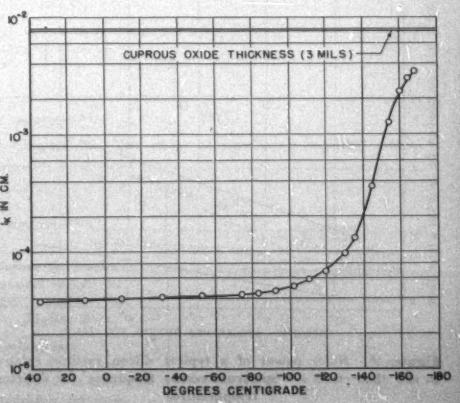


Figure 14 (right). Boundary layer thickness versus temperature

Copper-cuprous oxide rectifier ML14-2

gression to lower frequencies tends to restore the exponential relation. The slope of the straight line portion of the curve can be used to calculate the contact difference of potential. It is 0.48 volt, and is another bit of data useful for computing contact resistance.

It is of interest to see how the boundary layer thickness changes with temperature. As long as the mean free path for electrons in the semiconductor is short compared with the distance through the boundary layer to change the potential by kT, there should be no large temperature effect. Figure 14 shows that at about −80 degrees centigrade the conditions for the diffusion type of theory begin to break down.

Using the data given previously, along with atomic constants and assuming room temperature (297 degrees Kelvin), Schottky's formula predicts a contact resistance at zero volts of 1.6×10^{3} ohm-centimeters squared. Measured data* give 3.7×10^{3} ohm-centimeters squared. The calculated contact capacitance is 3.1×10^{-2} microfarad per square centimeter compared with 2.8×10^{-2} microfarad per square centimeter measured under the same conditions as the foregoing resistance.

We may conclude that the Schottky theory is a good start toward a detailed theory of the dry disk type of rectifier. The next urgent need is a discussion of the electrical fine structure of the boundary layer. When this knowledge is available the theory may be revised.

NOISE IN SEMICONDUCTING CONTACTS

Experimental observations on the noise generated in metal-semiconductor contacts indicate that in common with other forms of contact noise, the noise power per unit frequency is inversely proportional to frequency over several decades (10^{2} to 10^{6} cycles per second). This extra noise is large in comparison with Johnson (thermal) and shot (diode) noise for frequencies less than one megacycle. The nature of these forms of noise is illustrated in Figure 15. Shot noise arises in diodes because the flow of current across the diode is not continuous, but is the sum of a series of pulses due to the passage of individual electrons from the cathode to the plate. The noise current squared is proportional to the average current and the band width of the amplifier up to frequencies equal to the reciprocal of the transit time of the electron. The formula given in the figure neglects space charge. Johnson noise also

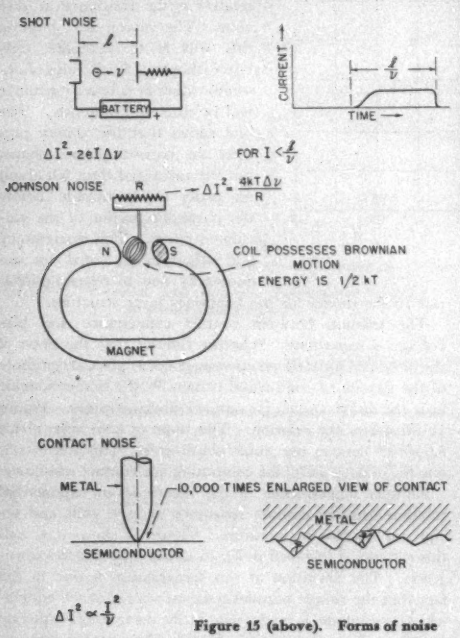


Figure 15 (above). Forms of noise

* Westinghouse type *SE*, 11/2-inch Rectox disk.

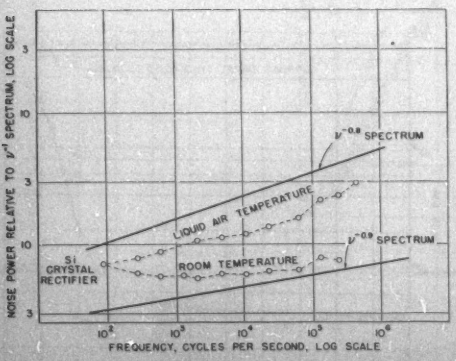


Figure 16. Noise power of a typical silicon rectifier relative to the theoretical ν^{-1} spectrum versus frequency for different temperatures

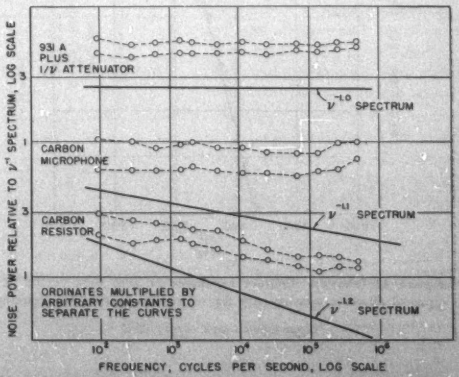


Figure 17. Noise power relative to the ν^{-1} spectrum versus frequency for carbon microphones and carbon resistors

exhibits the flat frequency spectrum and may be considered as the electrical analogue of Brownian motion. It is indicated in Figure 15 that the fluctuations in current flowing through the resistor may be thought of as giving rise to spontaneous motion of the coil in the magnetic field; or conversely, the Brownian motion of the coil in the magnetic field will give rise to fluctuating currents in the resistance. This noise is, of course, independent of any bias current flowing in the circuit.

The extra noise power is more nearly proportional to the square than to the first power of the current. The method of production of this noise is not well understood but is thought to arise in local changes in resistance in the immediate neighborhood of the junction of the metal cat whisker with the semiconductor base. If the changes in resistances are due to the motion of impurity atoms over the surface, or alternatively, motion in and out of the surface, one might think that the magnitude of the noise would be quite temperature-sensitive as diffusion rates vary exponentially with the reciprocal of the absolute temperature. Experiments have been made at the University of Pennsylvania on the temperature dependence of the extra noise and results for a typical silicon crystal rectifier are indicated in Figure 16. The results are plotted so that if the noise had a power spectrum inversely proportional to frequency the observations would fall along a horizontal line. If the noise falls off less rapidly than inversely with frequency, the points should lie along a line with a positive slope as indicated in the figure. Observations to date indicate that the temperature variation of the extra noise is not large. These experiments are difficult to design and carry out, because the theory does not indicate whether the voltage across the contact or the current through the contact should be kept constant as the temperature is varied. The contact resistance of course varies strongly with temperature; the mechanical stability of the contact is doubtful when the temperature variations are large. The University of Pennsylvania observations have been restricted to those crystals which reproduce room temperature d-c characteristics throughout several temperature cycles.

In Figure 17 are illustrated some observations made on carbon microphones and carbon resistors. The top curve illustrates the consistency of two methods of calibration of the instrument. The instrument is first calibrated by measuring the gain and band width of each of 12 selective amplifiers. Then the current from a *931A* photoelectric cell is allowed to flow through a network impedance which varies as the square root of the frequency. Thus the noise current squared varies inversely as the frequency when the photoelectric cell is illuminated with a constant intensity light source.

Transistors, when operating under normal conditions, are even noisier than crystal rectifiers and exhibit the same frequency dependence. When operating under normal conditions it is not uncommon to observe noise in the neighborhood of 1,000 cycles which is 10^6 times the Johnson noise in a resistance of 10,000 ohms at room temperature.

The theory of the frequency spectrum of noise due to density fluctuations has been intensively investigated. For instance, one might think of the work function being temporarily changed by the presence of an impurity atom

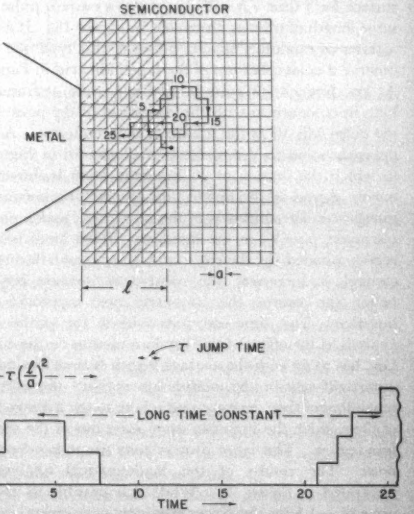
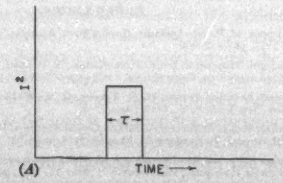


Figure 19. The effect of wandering impurity atoms



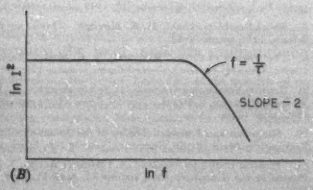


Figure 18. A current pulse due to an impurity atom on the surface momentarily with the noise spectrum due to random pulses of this type

A—Current pulse
B—Noise spectrum

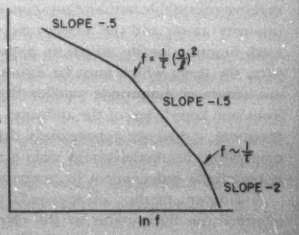


Figure 20. Mathematical results for the model of Figure 19

τ = jump time
a = interplaner distance
l = thickness in which modulation can occur

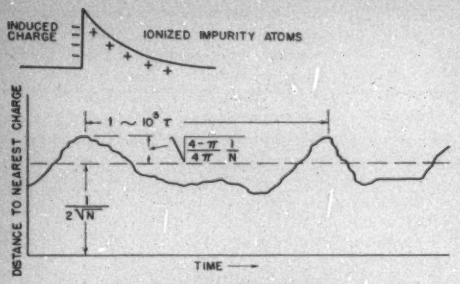


Figure 21. Proposed contact model involving a fluctuating potential barrier

$$\text{Fluctuation in potential } \Delta\phi = \frac{e}{K\tau}\frac{|\Delta r|_{av.}}{t} \simeq 10^{-3}\ \text{volt}$$

N = charge density
k = dielectric constant
τ = average distance to induced charge
$|\Delta r|$ = fluctuation in distance to induced charge

on the surface. Thus if an impurity atom appears on the surface for a time τ it will give rise to a current pulse of the same length of time as illustrated in Figure 18. If we have a series of randomly spaced pulses of this type one would observe a noise spectrum of the type indicated in Figure 18. At low frequencies noise is constant while at frequencies high in comparison with the reciprocal of the pulse length the noise falls off as the square of the frequency. A better approximation to the problem is illustrated in Figure 19, in which the motion of an impurity atom is shown as it moves around in the region near the metal semiconductor interface. The thickness of the barrier is l and it contains l/a layers parallel to the interface. If an atom is in this region (shaded on the diagram), the current through the contact is increased, the amount of increase becoming larger the nearer the impurity atom approaches the interface. Two time constants arise in the mathematical analysis of the effect of this random motion on the current. One has to do with the average length of time the impurity atom will stay in the modulation region; the other is a much longer time constant and relates to the average length of time which the impurity atom stays out of the modulation region. This latter process gives rise to low-frequency noise. The results of the mathematical analysis are illustrated in Figure 20. While it is possible to obtain a slope of -1.5 for the power spectrum over several decades in frequency there appears to be no way in which a slope of -1 can be obtained. It is possible with this model, by making reasonable assumptions concerning the number of impurity atoms and the amount by which they affect the work function locally, to obtain appreciable noise. However, the times which must be assumed for the jump time are orders of magnitude smaller than one would expect from our knowledge of the diffusion rates in solids. Furthermore, it does not appear likely that refined calculations employing this model would yield a noise spectrum which is essentially independent of temperature.

A different method of approach to this problem is to consider the fluctuations in the electric potential at the

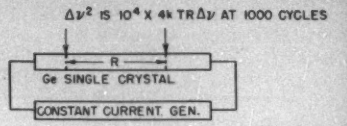


Figure 22. The H. C. Montgomery experiment

barrier. Although the work function of a region of the surface is well defined thermodynamically, there nevertheless will exist local variations in the potential barrier which an electron passing through the surface will experience. For instance, let us fix our attention at a particular point on the metal-semiconductor interface and consider the changes in the electric potential caused by the motion of the induced negative charges on this interface. The density of negative charges is of the order of 10^{12} electrons per centimeter cubed, so that on the average the nearest electron is about 50 interatomic distances away. If this induced charge exhibits a random motion then we should expect fluctuations in the potential hill in the region under consideration. The magnitude of these fluctuations may be as long as 10^5 times the jump time for motion of induced charges through one atomic distance. Figure 21 is a diagram illustrating this model which needs further development before one can tell if it is capable of accounting for the observed noise spectra.

So far we have been considering the source of noise as arising in the immediate neighborhood of the contact. H. C. Montgomery at the Bell Telephone Laboratories recently performed the experiment illustrated in Figure 22. A constant current was forced to flow through a germanium single crystal filament, and fluctuations of voltage between two contact points put on the filament were observed. The fluctuations in the voltage squared were about 10^4 times that observed in a resistance equal to that of the filament itself between the two contact points. Sufficient power was dissipated in the sample to warm it appreciably. This experiment indicates that there are either internal barrier resistances in a single crystal of germanium or that there are fluctuations in the number of electrical carriers within a "homogeneous" sample.

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Instruments for Studying the Welding Arc

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FOR THE purposes of this investigation, the number and duration of the short circuits in the arc and the degree of voltage and current fluctuation have been taken as an initial basis or criterion for stability measurements. Electronic circuits have been developed to detect and count all short circuits whose durations exceed a given specified time, such as a millisecond, and record the count on an electromechanical counter. The proportion of the total time that the arc is short-circuited is measured by a simple vacuum-tube circuit known as the short-circuit-duration indicator, and indicated on a suitably calibrated milliammeter. The average duration of the short circuits can be computed from the readings of these two instruments.

The indicator (see Figure 1) is essentially a simple d-c amplifier consisting of the tube T_1 and load resistance R. The arc is connected between the grid and cathode so as to make the grid negative. When the arc is burning, the grid is biased to cut-off and the tube is nonconducting. The occurrence of a short circuit decreases the negative grid potential sufficiently to allow full plate current to flow. This is indicated by full-scale deflection of the D'Arsonval milliammeter in the plate circuit. When the arc is short-circuited, full scale current will pass through the milliammeter, while no current will pass when the arc is burning. If the frequency of the short circuits is high enough in relation to the inertia of the meter, the milliammeter will indicate the average value of the current. The ratio of the milliammeter reading to the full scale reading is obviously the ratio of the short-circuit time to the entire time. If the milliammeter is calibrated in per cent, the instrument can be made direct reading.

Satisfactory operation of the circuit requires that the milliammeter current during a short circuit be absolutely independent of variations in the short-circuit voltage caused by the short-circuiting metal, and of any change in the plate supply voltage. Since modern tubes cannot be made to saturate, this requirement is insured by the addition of a clipping or by-pass circuit, consisting of the diode T_2 and the polarizing battery E_{bias} connected around the load resistance and milliammeter. As long as the current through the load is less than the predetermined value, the voltage drop across the load is less than the polarizing voltage on the diode, and the diode is nonconducting. When the load current reaches the specified value, the voltage drop exceeds the polarizing potential just enough to make the plate of the diode positive. Since the clipping circuit has negligible resistance, all current in excess of the specified value is shunted around the load, and the milliammeter current is limited to its full scale value. The values of E_{bias} and R are chosen so that the full scale current is one milliampere. The circuit elements used are as follows: tube T_1 is a *6C5* triode while T_2 is a *6H6* diode. The polarizing potential is provided by a 45-volt "B" battery, so that the resistance R is about 45,000 ohms. The final adjustment of R is made experimentally.

The rms value of the fluctuating component of the arc voltage is measured by a third instrument which has been

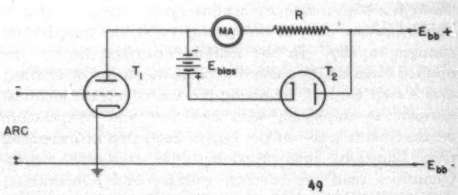

Figure 1. Circuit diagram of the short-circuit-duration indicator

designated as the rms voltage-deviation meter. A capacitance connected in series with a resistance across the arc voltage charges to the average value of the voltage so that the fluctuating component of the voltage appears across the resistance. This is measured by a vacuum-tube circuit and recorded by a recording milliammeter. A more sensitive modification of this instrument is used to measure the rms value of the fluctuating component of the current by taking the voltage drop across a low-resistance shunt, where the necessary resistance is the ratio of the expected rms voltage to the full scale meter current. Each of these instruments is built on an independent steel chassis and provided with its own power supply so that it is readily portable. In the laboratory, the units are mounted one over the other on a steel rack so that they can be easily adjusted and read from one position.

These instruments now are being used in the laboratory as an aid to the study of the welding arc over a wide range of arc current and voltage, and for a variety of electrode coatings. The results obtained are supplemented by such measurements as the arc length, weld penetration, and spatter loss. Preliminary results indicate that the instrumentation is capable of distinguishing between different types of electrodes and different test conditions. Final evaluation of these instruments must await the results of more extensive tests which are now being conducted. It is possible that one or more of the instruments will prove superior to the others and be adopted for further use. On the other hand the results may suggest that some modification in instrumentation would be desirable.

Digest of paper 49-131, "Instrumentation for the Evaluation of the Stability of the Welding Arc," recommended by the AIEE Instruments and Measurements Committee and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Dielectric Loss With Changing Temperature

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INDUSTRIAL dielectric heating by high electric frequency, for curing or thermosetting, frequently involves heating cycles over the range 20 seconds to four or five minutes duration, for temperatures up to 250 degrees Fahrenheit. Rates of temperature rise up to 400 degrees Fahrenheit per minute or more are common.

Of present available methods of measurement of dielectric properties under alternating stress, all apparently without exception are limited to the steady-state condition with temperature constant. For two principal reasons, such methods are not suitable for following the dielectric through a high-frequency heating cycle: the low value of applied stress; and, in the heating cycle, the temperature changes rapidly. In the method described herein, the applied stress is high enough to cause the dielectric heating, and a step method, involving the use of several identical samples, is employed, with electrical and temperature measurements made at the end of each step of increasing time duration, thus obtaining the complete curves. Quantities read are current, voltage, and temperature, the last by means of thermocouples imbedded in the mass of the sample. The power component of the current is obtained by d-c calibration of the cell with an identical sample in place, the latter being heated by thin grids within its mass. The energy input for any rate of temperature rise thus is determined, and with the a-c values, leads to simple computation of dielectric constant, loss and power factors, and energy input, for any point on the temperature-time curve.

Figure 1 shows the cell and connections for measurements at 30 megacycles. *A*, *A* are duplicate samples, and *B* is the thin high-voltage electrode between them; *C*, *C* are insulating backings for the guard-ring low-voltage electrodes *G*, *G*; *D*, *D* are the walls of the cylindrical thermally insulating cell; *F*, *F* are thermoammeters, and *T* one of the several adjustable thermocouples; *H* is the electrostatic screening system, which must embrace separately each of the component parts.

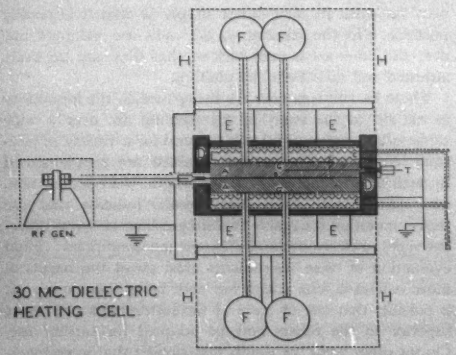

Figure 1. Test cell for measurements at 30 megacycles

In order to insure uniformity of temperature in the test sample, it was found necessary to preheat the electrodes. This was done by inserting thin-sheet nichrome heating grids in the insulating backing (*C*, *C* in Figure 1) of the low-voltage electrode, and using a duplicate sample on the back face of the high-voltage electrode. Auxiliary measurements insured that no heat entered the sample from the electrodes, and that uniformity of temperature of the sample was attained closely.

MEASUREMENTS

Dry Materials. The normal heating or temperature-time curve of a dry thermosetting material is concave upwards. The slope of the corresponding current-time curve at first increases, then increases more slowly, finally passes through a maximum, and then decreases rather sharply. The result of this relationship is a curve of loss factor and one of dielectric constant, both at first increasing and each passing through a maximum approximately in step with the current maximum.

Materials Containing Moisture. It is a long process to dry powders and preforms completely, and a relatively small amount of residual moisture causes an important variation of the behavior just described. In such cases, the maxima of current, loss factor, and dielectric constant all appear, but earlier and in more pronounced character than in dry materials. This effect is apparently due to the increased absorption and power for driving off water.

SUMMARY

1. A method of measuring the properties of a dielectric while its temperature is changing has been developed and applied to certain thermosetting materials under high-frequency heating.

2. The presence of absorbed moisture in small amounts has a pronounced influence on the dielectric properties of such materials.

3. Two basic phenomena are active in dielectric heating at high frequencies: dielectric absorption (in the Maxwellian sense); and some form of molecular polarization. The former is evident in high-stress short-time heating cycles. The latter is the more important for the thermosetting process, and is completely developed in longer lower-stress heating cycles.

4. The method provides a simple means of determining the total energy input per cycle and per cubic centimeter of the material under study.

Digest of paper 49-130, "The Measurement of Dielectric Loss at High Frequencies and Under Changing Temperatures," recommended by the AIEE Electric Heating and Instruments and Measurements Committees and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer General Meeting, Swampscott, Mass., June 20-24, 1949. Scheduled for publication in AIEE *Transactions*, volume 68, 1949.

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Trends in High-Voltage Cable Transmission

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Use of underground high-voltage cable transmission at 220-kv may be possible in the near future. Many new ideas in this field are visionary and uneconomical, but eventually they will result in improved transmission. The author describes earlier types of cables, developments during the past 25 years, and improvements that may be expected in the near future.

DURING the past quarter of a century, high-tension cable transmission has been going through a most interesting and extensive process of evolution, but the frontiers of this field have not been reached. It is gratifying to note that the cable engineer has not been resting on his oars. The numerous problems are being aggressively investigated and persistent activity in finding better technological and economic solutions is still strongly in evidence.

About 25 years ago high-voltage cable transmission had reached the 69-kv class. However, practice in the United States still was following the long-established "solid" insulation idea, mainly dependent upon increased thickness of paper insulation, impregnated with heavy compound, to withstand the higher voltages. The cable was sheathed with lead and drawn into duct. At that time, foreign cable engineers were making great strides in the development of "oil-filled cable" of greatly improved paper quality and degassified thin oil under pressure in the range of 10 to 15 pounds per square inch. Also, various refinements in factory processes and field procedures made possible drastic reductions in insulation thickness for a given voltage service. These cables were covered with lead sheaths and, in the United States, duct installations persisted.

These advances in oil-filled cable made possible the economic use of cable for 132-kv service and established the technical feasibility of cable for even higher voltages. In consequence there was wide acceptance at a rapid rate of the oil-filled cable idea in the United States.

During the early 1930's cable developments were getting under way along quite different lines. This refers to the three types commonly called "Oilostatic," "gas-pressure," and "compression" for the voltages of 69 kv and upwards. These employ "high" pressures (in the 200 pounds-per-square-inch class) to provide suitable insulation performance.

The Oilostatic type is characterized by what was then generally considered a radical departure, namely, the utilization of a steel pipe to contain conductors with their paper insulation immersed in high-quality insulating oil.

The gas-pressure type also uses a steel pipe as a container. It is characterized by the conductors and their insulation being immersed in a pressure medium of nitrogen dried to a very high degree. The gas is in direct contact with the paper insulation which is so applied and impregnated as to control the effects of gas within the insulation. The compression type of cable, developed in Europe, utilizes substantially conventional "solid" paper insulation in a thin wall. The insulation is compressed by oil or gas in the pipe acting through an impervious, pressure-transmitting sheath, which separates the insulation from the pressure medium.

Alternatively to the generally used steel pipe with wall thickness in the range of one-quarter inch, diameter of five to eight inches, and a corrosion-protective covering, the types of cable utilizing gas as a pressure medium could employ reinforced sheaths to withstand the high pressure. There are some such installations in Europe.

With the tremendous expansion following termination of war controls, there has been a pronounced trend toward pipe-type cable systems and away from the low-pressure oil-filled type with lead sheath, installed in duct.

There had been grave doubts in the minds of many operating company engineers as to the practicability of pipe-type cable systems, particularly in respect to the long-time integrity of the pipe, suitable methods for protecting it against corrosion, methods of locating electrical faults and pipe leaks, length of time required for making repairs, and carrying capacity limitations due to the pipe. However, numerous installations were made, some on an experimental or semiexperimental basis, and a great deal of study has been carried on by both cable engineers and operating engineers to solve these various problems.

It was early realized that the pipe-type cables offered substantial economic advantage and this was, of course, a major incentive to their use. The pipe-type systems, in some respects, involve fewer construction difficulties, particularly under many metropolitan area conditions. The cross-sectional area of the structure is smaller, and avoidance of other underground structures is often much easier. The number of manholes is reduced to a fraction of those required in the duct-type construction, with correspondingly fewer splices. On the other hand, in the pipe-type system, cable repairs may involve withdrawal of a much greater footage of cable. This particular problem, however, is being attacked by the development of methods for opening up the street at the point of failure and, through various techniques, making repairs with the replacement of only a relatively few feet of cable in the vicinity of the failure.

It seems safe to observe that under present economic conditions, the pipe-type of cable offers definite savings, but the magnitude of these may vary a great deal. Prices of

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materials, manufacturing costs, and local installation conditions can produce wide differences. Only long experience will determine relative operating and depreciation costs.

There has been much criticism of all these modern high-tension cable systems for the refined "laboratory" procedures that must be followed in the field during construction with resultant serious cost increases. It is certain that both the designing and construction engineer must devote more attention to eliminating refinements that may have crept in through the natural desire to improve the over-all job. Small over-all improvements may have been accomplished at the expense of unwarranted costs. This situation presents a serious challenge to every cable engineer.

These observations deliberately avoid involvement in a number of technical matters which are still the subject of debate and investigation or await the definite answers that can be secured only from extended operating experience. Some of these are the long-time effectiveness of the generally used pipe covering as protection against corrosion and electrolysis, the detection of pipe leaks, and the high transient stresses in the pipe structure resulting from heavy fault currents with oil as a pressure medium.

Power losses in pipe-type cables are being given long overdue attention. The effects of close conductor proximity, steel pipe, conductor stranding and segmentalizing, and shielding and armor wires require thoroughgoing analysis in order to control the over-all losses with large size conductors.

There are also the basic matters of permissible temperature rise, continuous and short-time load ratings, insulation losses, and cable life associated with the relatively new gas-pressure installations having insulation permeable to gas, as compared with the time-proved insulations in which gas exclusion is nearly complete. There are questions as to the endurance of the pressure-transmitting coverings which separate the gas or other pressure medium from the insulation in the "compression" type of cable.

These and many other questions are being given extensive study. The answers greatly will influence the future trend which may be either toward the predominance of one of the present types or toward a wide diversity of types, each with its advocates. In principle, progress will be most effective if it leads to virtual standardization on one type, and that need not be one of those types of cable already described.

Now that the past and present in the field of high-tension underground transmission have been surveyed, it seems worth while to look into the future, without attempting to forecast or predict, but for the purpose of pointing out certain trends and newer developments. Continued investigation by cable engineers is essential in order to meet the challenge of present high-cost levels by simplification, standardization, economy in use of materials, and the development of improved methods.

Ideas that today are visionary and not in the economic range, eventually may provide the necessary means for improving the utilization of high-tension cable transmission. It does not seem too visionary to expect that the coming years will bring in this country an appreciable use of underground transmission at 220 kv, naturally first where right-of-way costs and congested conditions make overhead transmission more costly, or public convenience or necessity are unfavorable to overhead transmission.

Now let us examine a few ideas which have been worked upon but have not yet been accorded much if any degree of acceptance, and some ideas, perhaps as yet in the "dream" stage, which may warrant expenditure of technical talent and engineering ingenuity, to see where possibilities can be developed into certainties leading to new methods in reliable transmission on a higher level of economy.

One idea, discussed for the past few years, is the utilization of polyethelene extruded over the conductor instead of the long-established insulation of wrapped paper tapes, impregnated with oil or heavy compound. The engineer recognizes that polyethelene is a thermoplastic, subject to softening and therefore possible deformation at temperatures of about 100 degrees centigrade, and requires pressure to maintain its electrical integrity under high-voltage stress. Other new synthetic materials may be developed suitable for insulation, and adapted to cheap, rapid extrusion methods for their application. It is possible that low-cost liquids, such as water, can be used as the pressure medium, to provide thermal conductivity superior to gas.

Also, it is possible that the pipe containing the insulated conductors can be of a nonmetallic material, impervious to gas or liquid, or rendered impervious by applied coatings. The utilization of such a pipe confronts the engineer with many problems, such as jointing, strength to withstand bursting, external damage, settlement of the soil, and so on. However, the parasitic losses of steel pipe would be eliminated, the disadvantageous shielding effect of steel in locating faults would be removed, and complications with present external corrosive-protective coverings would be avoided. Decreased conductor cross section would be possible but supplemental shielding or other cross-sectional area, required to assure adequate return paths for fault currents and proper relaying, would have offsetting effects.

Perhaps further investigation should be made of pressures higher than the present 200-pounds-per-square-inch class, in order to determine whether further economies in insulation can be realized without offsetting pipe and jointing costs. Other gas pressure mediums may be found superior to the present preferred nitrogen.

There are undoubtedly a number of other lines of investigation that may have occurred, to those close to the problem. Engineers in a supervisory capacity should not discourage investigation along new lines, but are urged to listen to and constructively weigh ideas that may be offered. I venture to suggest that many of these will come from the younger men who "do not know that it cannot be done."

The concluding observations, which follow, are derived from engineering that has been found necessary with the pipe types of cable. The development and engineering of the cable manufacturers has not fully anticipated installation and operating problems and, in some respects, fundamentals of design should have been more thoroughly investigated. On the other hand, the operating companies must take responsibility for fully informing the manufacturers of the operating problems. Even more than with the early types of cable, it is essential that the design and operating engineers work in close co-operation.

Electrical Essays

Electrostatic or Electromagnetically Induced Electric Field?

By measuring the alternating force on a *stationary* small charged probe whose position is varied it is discovered that an alternating electric field exists outside of a black box made of insulating walls. The field configuration is shown in Figure 1.

It may be that the electric field is set up by charges being supplied to metallic plates, *A*, by an alternating source as in Figure 2.

Or it may be that the black box contains a toroidal magnetic core *B*, through which an alternating magnetic flux is passing, as in Figure 3.

Figure 1. Electric field outside black box

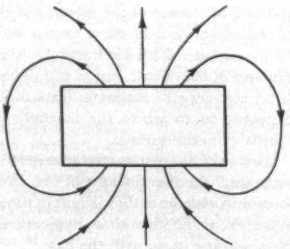


Figure 2. Electrostatic field

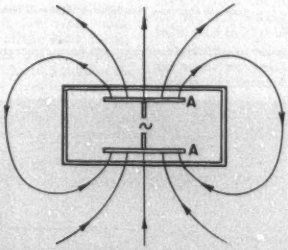
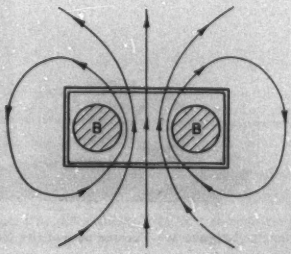


Figure 3. Electromagnetically induced electric field



In many places in electrical engineering literature these two types of electric field are said to be fundamentally different in nature. Thus, most recently, G. I. Cohn,* on page 445 of his article, "Electromagnetic Induction" (*EE, May '49, pp 441–7*) speaks of the induced field of Figure 3 as "(hypothetical)", presumably in contrast to the "real" electrostatic field of Figure 2. The electrostatic field, which is presumably not "(hypothetical)", has a scalar potential of which it is the gradient, whereas the best we can do for the electromagnetically induced "(hypothetical)" field is to make it the time derivative of the vector potential of the magnet induction. (Equations 43 and 40, page 445 of afore-mentioned article).*

Now with all this important difference between the electrostatic and electromagnetically induced electric fields, go back to Figure 1, and by suitable observations or by making the proper measurements, determine which type of electric field is present. Of course you must not peek into the black box.

J. SLEPIAN (F '27)
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Another Nonlinear Circuit

Two identical transformers and a rectifier are connected in series as shown in Figure 1 and are energized from a source of rated voltage and frequency. For simplicity the following assumptions are made: unity turn ratio, no losses,

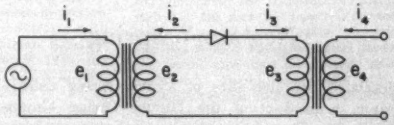

Figure 1

no saturation, and no impedance drop ($L_1 = L_2 = M$). An ideal rectifier is also assumed with zero voltage drop when conducting, and infinite resistance when blocking. Since no copper or iron loss is assumed and transient components cannot decay, the transient components are eliminated at the start.

Consider the following questions. What voltage

* In my essays, generally I have given no literature references, as compiling such would be burdensome, and since I make no claim to scientific novelty in these essays. However, in this essay I do refer to Cohn, firstly, because of the very high excellence of the article, secondly, because of its pertinence to the subject of this essay, and thirdly, because it has appeared so recently in *Electrical Engineering*.

appears at the open terminals of the circuit? What are the currents?

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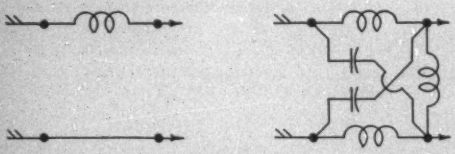
Answers to Previous Essays

Two Boxes. The following is the author's answer to a previously published essay of the foregoing title (*EE, Sep '49, p 763*).

The engineer notes that the input current to box *1* is equal to the output current and deducts that the box contains a series impedance. Since there is no loss in the box, it is a pure unit reactance.

The input current to box *2* is proportional to the output



Box 1 **Figure 1** *Box 2*

voltage. This is a characteristic of the Steinmetz network with unit Ohm branches. However, the Steinmetz network has an infinite impedance at each pair of terminals when the other pair of terminals is short-circuited. He notes that this is true at the input terminals. At the output terminals, however, the impedance is a unit ohm reactance (Thévénin's theorem) which can only mean that the output terminals are shunted by a unit ohm reactance. The engineer reconstructs the circuits of Figure 1 on the basis of his deductions.

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Magnetic Control of Mutual Induction. The following is the author's answer to a previously published essay of the foregoing title (*EE, Sep '49, pp 762–3*).

My Alter Ego has again been taking the words of his friends, the electrical engineers, too literally. The reality in the electromagnetic field in space, or rather, what appears in Maxwell's equations, is two vector fields, the electric and the magnetic field respectively. Each field gives us at each point in space, a direction, and a magnitude and that is all. Maxwell's equations say nothing about lines of force, and whether particular lines of force close or not, and whether they link one or more circuits seems to be irrelevant to Maxwell's equations.

The electromotive force induced in a closed circuit, by which is meant the integral of the electric force around that closed circuit, is, according to Maxwell's equations, equal to the rate of change of the integral of the normal component of the magnetic field taken over a 2-sided surface bounded by the circuit. This last integral is frequently called the flux linkages of the circuit, but in this definition thus given there is no reference to magnetic lines of force, or any concern expressed as to where the magnetic lines may go as they recede from the surface.

Two circuits are inductively coupled if, with "other things constant," the flux linkages of one circuit, as defined in the foregoing, change as the current in the other circuit is varied. Whether, at the same time, magnetic lines link both circuits "has nothing to do with the case."

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"Neg'ator" Spring

Illustrated are five uses of a new spring called the Neg'ator, a product of the Hunter Spring Company, Lansdale, Pa. By subjecting the metal tape of which the Neg'ator is composed to a prestressing process, the spring can be made to give a decreasing restoring force with increasing deflection. Also, the tape can be treated so as to have a flat force-deflection characteristic. Attributes of the Neg'ator are: usable deflections as high as 30 to 50 times its original dimension (the usual extension spring expands 1/2 to 2 times its original length); the ability to act around corners and through small openings with the same freedom as nonelastic bands; high initial force at initial deflection; and the capacity to deliver twice as much energy as an ordinary spring occupying the same space. The Neg'ator is treated so that it naturally forms a tight coil. It is shown as a: self-winding tape; clip; clamp (two 1/2-pound disks held with 16 pounds pressure); telescopic tube; wrapping.

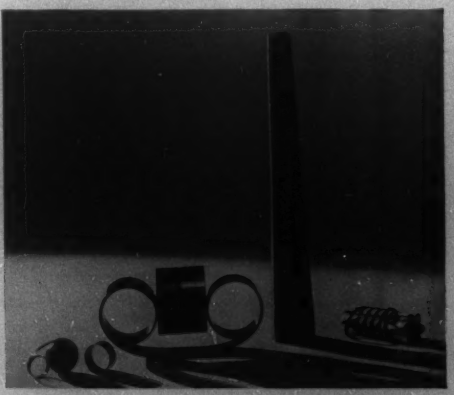

Figure 1. Various uses of the Neg'ator spring

Conference Papers Digested for Pacific General Meeting

These are authors' digests of most of the conference papers presented at the AIEE Pacific General Meeting, San Francisco, Calif., August 23-26, 1949. These papers are not scheduled for publication in AIEE Transactions or AIEE Proceedings, nor are they available from the Institute.

Electric Load Growth in California for the Next 20 Years; *Robert P. O'Brien (Public Utilities Commission, State of California, San Francisco, Calif.).*

Reduced to its simplest terms, a forecast of electric load requires only a determination of the number of people to be served and an evaluation of what they are doing and how intensively they are doing it. Analysis of historical records, and the trends shown thereby, comprise the basis for such forecasts. Extension of such trends into the future can prove no more accurate than the degree to which future influences coincide with present assumptions.

Forty per cent of California's 100 million acres is held in the public domain, about half in forests and parks. Thirty-five million acres of farm land support approximately 140,000 farms. Many mineral deposits are known. Petroleum, the most important mineral industry, has produced twice as much wealth in the past 60 years as all others combined. In terms of labor, trade and service activities support 40 per cent; manufacturing, 20 per cent; agriculture, forestry, and fishing, 10 per cent; and government 12 per cent of the labor force. California population has increased from less than 100,000 in 1850 to 10.3 million in mid-1949, and from less than one-half of 1 per cent to almost 7 per cent of the nation's total. Since 1920, about 85 per cent of the growth was the result of in-migration. The fluctuation in economic activity reacts on the growth rate. During the five depression years, annual population growth averaged 12 thousand persons in natural increase and 60 thousand from net movements from other areas. Postwar, the rate of natural increase is 9 times and the in-migration 6 times as great. Since 1920, the heaviest growth has been in the urban population and the nine counties in Southern California. By 1960, California's population is expected to approximate 13.5 million with a possible spread of 1–1.2 million. Urban population is estimated at 78 per cent and Southern California at 54 per cent. 1970 estimate shows a spread from 14.4 to 18.0 million, with percentages of 80 per cent and 55 per cent to urban and southern elements.

Electric customers have grown from 870 thousand in 1920 to almost 3.3 million in 1948, of which 2.6 million were residential and 490 thousand, commercial. Customers in 1960 are estimated at 4.8 million and in 1970 at 6.0 million.

Electric sales have increased almost tenfold, from 2.5 billion kilowatt-hours in 1940 to 20.3 billion kilowatt-hours in 1948. Although in 1920 Northern California sales were half again as large, sales had reached equal levels by 1948. Average annual compound rate of growth from 1920 to 1940 in Northern California was 6.3 per cent and in Southern California 8 per cent. Comparable rates during the war were 11.7 per cent and 13.1 per cent. Postwar rates for the state, as a whole, were 1946, 2 per cent; 1947, 12 per cent; and 1948, 8 per cent. Sales in 1948 were 4.1 billion kilowatt-hours residential, 419 billion commercial, 6.8 billion industrial, and 2.7 billion agricultural.

Residential sales have increased from 918 kilowatt-hours per customer in 1938 to 1,545 kilowatt-hours in 1948. Further increases are anticipated because of greater appliance saturation. Estimates of unit consumption for 1960 and 1970 range from 1,900 to 2,300, and from 2,300 to 2,600 kilowatt-hours. Consumption at intermediate levels would produce sales of 8.0 billion and 11.8 billion kilowatt-hours.

Unit commercial sales increased from 5,400 to 10,600 kilowatt-hours per customer from 1938 to 1947, with a slight drop in 1948. Estimates for 1960 and 1970 commercial sales under intermediate assumptions total 10.8 and 15.3 billion kilowatt-hours.

Industrial sales climbed from 2.8 billion kilowatt-hours in 1938 to a wartime peak of 8.1 billion; dipped to 6.1 billion in 1947. The 1944 growth of 2.3 billion was an increase of 42 per cent over the previous year. Sales in 1960 are given a possible spread of 7.6 to 18.9 billion kilowatt-hours and in 1970, 12.4 to 27.9 billion.

Agricultural sales, largely used in pumping water for irrigation and susceptible to wide swings because of variations in precipitation and in market conditions which have increased from 0.9 billion kilowatt-hours in 1938 to 2.7 billion in 1948, are given a spread of 3.4 to 5.5 billion in 1960 and 4.7 to 7.7 billion in 1970.

Sales for other classes of customers, totalling 1.8 billion kilowatt-hours, and consumption of large blocks of energy in current and potential large scale water developments are recognized.

Historical differences between sales and production show a gradual improvement in the ratio of sales to production from a 60–70 per cent factor in 1920 to 75–80 per cent in recent years. Annual load factors except for the war period approximate 60 per cent. Estimates of load and demand at generation increased from 0.7 million kilowatt and 3.8 billion kilowatt-hours in 1920 to 4.8 million kilowatts and 25.7 billion kilowatt-hours in 1948. Estimates at alternative levels of growth indicate 1960 loads of 37 to 64 billion kilowatt-hours and 7 to 12 million kilowatts, and 53 to 90 billion kilowatt-hours and 10 to 17 million kilowatts in 1970. Recognizing the prospective wide variation which may occur, the magnitude of growth presents tremendous financial, technical, constructional, and operational problems to be solved.

The New Swedish 380-kv System Now Under Construction; *Åke Rusck, Bo G. Rathsman (Swedish State Power Board, Stockholm, Sweden).*

Of the total water power resources in Sweden, 85 per cent are in the north and 15 per cent in the southern parts of the country whereas the distribution of power demand is the reverse. For transmission of power from north to south an extensive 220-kv system has been developed now comprising five, and before the end of 1949, six parallel lines. The rapid increase of power demand after the war and the decision in 1946 to harness Sweden's largest waterfall, Harsprånget, 20 miles north of the Arctic Circle, have called for the introduction of a transmission system with a larger carrying capacity. Economic comparisons indicated that the optimum would be reached by a-c transmission for about 380 kv and in December 1946 this was decided upon.

In its first stage, the 380-kv plant will include step-up transformers at Harsprånget, a 593-mile single-circuit line from Harsprånget to Hallsberg, a step-down 380/220-kv transformer station at Hallsberg and a 380/220-kv transformer station at Midskog, half-way between the two terminals, interconnecting the 380-kv line with the 220-kv bus bar of the present principal generation district. The system will be designed for operation with solidly grounded neutral. Due to the exceptionally high-voltage rise when one of the line sections is disconnected at one end, and the desirability to secure an adequate arrester protection, the station insulation has had to be specified for an impulse withstand voltage of 1,775 kv on 1/50 full wave. The line insulation will consist of suspension strings with 20 to 23 units and an impulse strength of about 1,600 kv. At Harsprånget the aggregate power from the three generators totalling 290 megawatts is fed into one transformer bank for stepping up the voltage to 380 kv. From the generator and transformer plant installed in the rock the power is carried by cables to ground level. The transmission line has welded high-grade steel towers of the portal type and an average span of 1,080 feet. Double conductors with two 1.170.000 circular mils steel-aluminum cables per phase are used, reducing the line reactance by 26 per cent. The receiving end station will have two 380/220-kv transformer banks, shunt reactors of 120 megavolt-amperes, and a hydrogen-cooled synchronous condenser of 75 megavolt-amperes. The midpoint interconnection is made up of one 380/220-kv transformer bank and a phase shifting transformer on the 220-kv side facilitating an economical load distribution between the 380-kv system and the parallel connected 220-kv lines. Shunt reactors of totally 300 megavolt-amperes are installed in Harsprånget and Midskog. Each one of the 380-kv transformer banks comprise three single-phase units, those in Harsprånget and Midskog with an additional unit as a stand-by. Voltage regulation under load is provided by separate transformers connected to the neutral point of the 380-kv side. The circuit breakers will be of the air-blast type and have an inter-

rupting capacity of 8,000 megavolt-amperes at 380 kv. Relay protection for the lines will be furnished by distance protection with supplementary carrier current protection. Arresters will give adequate lightning protection. The line will be capable of transmitting about 400 megawatts with a reasonable stability margin. At this load the total losses for this 600-mile transmission will be about 8 per cent. After the line is completed at the beginning of 1951 it will be operated at 220 kv until the beginning of 1952 when operation at 380 kv will start. The total cost of this 380-kv system is estimated at 36 million dollars not including 28 million dollars for the generator plant at Harsprånget. The first line soon will be followed by a second one, about 300 miles long, expected to be completed by 1953.

Application of Series Capacitor and Double Conductors in the Swedish Long-Distance Transmission System; *Åke Rusck, Bo G. Rathsman (Swedish State Power Board, Stockholm, Sweden).*

Because of the large transmission distance of the existing 220-kv and the future 380-kv systems in Sweden, stability is the principal limitation for loading the lines. To increase the transmission capability a series capacitor is now being installed in one of the 220-kv lines and double conductors are introduced on the 220-kv and 380-kv lines under construction. The series capacitor is inserted near the midpoint of a 300-mile line. It will consist of normal shunt capacitor units with a total nominal rating of 31,000 reactive kilovolt-amperes, combined in series and parallel so as to compensate 20 per cent of the line reactance increasing the permissible line load by about 30 megawatts. The capacitor bank will be protected against overvoltages by a spark gap connected in parallel and adjusted to ignite at short circuits on the compensated line. At short circuits outside the line terminals, the overvoltages will not become dangerous to the capacitor which therefore may be kept in service. The spark gap is mounted on an isolated platform together with a by-pass circuit breaker connected in parallel with the gap and the capacitor. The capacitor units are isolatedly suspended in a steel structure designed for a future extension of the bank to 30 per cent compensation. The cost of the additional transmitting capability achieved by the capacitor is about 85 per cent of the specific transmission cost of a new 220-kv line. The plant will be in operation at the end of this year.

The use of bundle conductors, which reduce the line reactance and raise the corona level is of special advantage for a large power transmission such as the Swedish 380-kv system. The optimum was found to be reached by double conductors consisting of two 1,170,000 circular mils steel-aluminum cables with a spacing of 18 inches and these conductors will be employed on the 600-mile line now under construction. Also, for long 220-kv lines a reduced reactance is of great value. Approximate calculations show that the additional power transmission achieved by double conductors on 220-kv lines normally is obtained at a somewhat lower cost than by construction of new 220-kv lines. Two new lines, totalling 260 miles, now are being built with two 650,000 circular mils steel-aluminum per phase. An existing line will be rebuilt with double conductor in 1950. To prevent the cables from clashing and to make the double conductors function in the intended way, the mutual distance must be controlled. Calculations and tests of conductor movements due to electrical forces and to wind show that spacers should be used to confine the free length of cables to 430 feet on the 380-kv line and about 560 feet on the 220-kv lines. The spacers are designed so as not to restrain the longitudinal movements of the cables. They are installed after the cables have been strung by a lineman working from a small carriage which rolls along the two parallel connected cables.

A New Aircraft D-C Generator Control System; *G. E. Phillips (General Electric Company, Schenectady, N. Y.).*

Requirements of new, large commercial and military aircraft have placed demands on the electric system designers for improved protection as well as for a new concept in over-all physical arrangement of components.

In general, older generator systems provide, in addition to the generator, only a voltage regulator and a reverse current cutout. Experience now has shown that adequate ground fault protection for both welded and arcing types of faults and overvoltage protection for wide speed range generators is necessary. In order to provide power system reliability and a reduction in the hazards of fire and smoke, as well as damage to other equipment from electrical faults, the provision of such protection in a reliable manner has been a primary consideration. Also, the use of stronger equalizing circuits for load division in newer systems has necessitated protection against dangerous reduction in system voltage from out-of-service generators.

Besides electrical performance, the limitations of aircraft design and operating problems have a considerable bearing on the electric system arrangement. For example, in large multiengine aircraft the location of the main bus is usually relatively inaccessible, since, from the standpoint of minimum weight, the bus must be in the fuselage near the front wing spar. This locates it in the bomb bay on military aircraft and in the passenger cabin or baggage compartment on commercial airplanes. Therefore, it is desirable to locate only the main power carrying devices at the bus, and to put the voltage regulator with other control and protective devices in a more accessible location for ease of maintenance and servicing. Simplicity and interchangeability of equipment amongst various types of aircraft are also important factors.

A system has been designed with these considerations in mind. It consists of a main power contactor and a direct acting reverse current circuit breaker for location adjacent to the airplane main bus and a drawout-type control and protective panel which may be placed in any other convenient location. The reverse current feature provides a high degree of system reliability whereas differential current protection and overvoltage protection are incorporated to minimize the hazards of fire and damage to equipment from arcing faults and high system voltages. The drawout panel construction is effective in decreasing ground delays on commercial airplanes, and makes bench testing and adjustment of equipment possible. Standardization for all kinds of aircraft and various sizes of generators simplifies the stocking of parts and handling of spare equipment.

Systems have been designed, built, and tested not only for existing 28-volt d-c airplanes, but also for future 120-volt d-c airplanes.

30-Volt and 120-Volt D-C Aircraft Circuit Breakers; *Paul J. Raifschneider (General Electric Company, Philadelphia, Pa.).*

The electric systems of many modern airplanes, particularly the generator circuits of multiengined airplanes, are being operated without adequate electrical protection. This practice is quite different from that usually followed in other electric systems. Circuit breakers with adequate continuous current and interrupting capacity, tripfree mechanisms, manually and electrically closed, and with suitable fault-sensing elements, offer the best means of protection. To provide the much-needed protection, new aircraft circuit breakers have been developed with ratings of 300 and 600 amperes at 28 volts and 250 amperes at 120 volts direct current. The interrupting ratings over a range of altitudes from sea level to 50,000 feet are 12,000 amperes and 5,000 amperes for the 28-volt and 120-volt circuit breakers, respectively.

Two parallel bridging contacts in the 28-volt circuit breakers provide sufficient conducting cross-sectional area for the maximum rating of 600 amperes. The use of hard white vulcanized fiber as a gas producing material has resulted in a highly efficient and compact interrupter for 120 volts. The gases evolved are permitted to build up the pressure in a tight enclosure helping considerably to extinguish the arc and withstand the recovery voltage.

One of the outstanding features of the mechanism of these circuit breakers and one that makes it different from earlier aircraft circuit breaker mechanisms is that it is tripfree. The contacts of these circuit breakers open fully and quickly if tripped while the mechanism is in the process of being closed or while the mechanism is held in the closed position.

Either directional or nondirectional trip devices with instantaneous or inverse time characteristics can be incorporated in these circuit breakers. The selection of the type of trip device and its setting depends upon the application of the circuit breaker in the electric system. For generator circuit applications an inverse time delay reverse current trip device is usually used. The inverse time current characteristic prevents the circuit breaker from tripping falsely on transient reversals and allows the circuit breaker to tip instantaneously on reverse currents of 2,000 amperes or more. This tripping characteristic is very desirable for generator circuit applications because of the protection which is provided throughout the entire range of currents.

A shunt trip device is provided in these circuit breakers for remote tripping over a wide range of system voltages.

Applications other than generator circuits

for which these circuit breakers may be used are bus sectionalizing and single and dual channel feeder circuits and load circuits.

Some Factors Which Affect the Load Characteristics of Electrically Heated Homes; *Buford H. Martin* (*Tennessee Valley Authority, Chattanooga, Tenn.*).

The use of electricity for home heating has gained great impetus in the Tennessee Valley during the past three years. At the end of June 1949, there were 18,000 homes completely heated by this means.

The area has a moderate but variable climate. The heating season is of about 220 days' duration, and the average annual degree days will range from 2,500 in the southern part to 4,500 along the northern boundary.

The Tennessee Valley Authority and several of the agencies distributing TVA power have co-operated in collecting and analyzing considerable data relative to the effect of the house heating load on the distribution systems serving it.

Some of the more important factors affecting the load characteristics of the electrically heated home are the installed capacity of the heating system; type of construction and degree of insulation of the house; outdoor temperature; type of heating system used; and the use of load regulating devices.

By the use of adequate insulation, the required capacity of heating systems often may be reduced as much as 50 per cent. When several homes are involved, this reduction in the installed heating load will result in reducing peak demands.

Data collected from three groups of electrically heated homes, totalling 81 houses, afforded information for preparing feeder load curves for various temperature ranges. These homes are of 2- and 3-bedroom size, and have an average connected heating load of 13.4 kw. The maximum feeder demand for all electrical uses averaged 9.8 kw per house.

These studies, although yet incomplete, provide sufficient data to indicate the type of load curve resulting from a group of electrically heated homes and the benefits which may result from the use of load regulating devices.

Heat Pump Experience in Portland, Oreg., Area; *W. E. Gordon* (*Portland General Electric Company, Portland, Oreg.*).

Oregon in general, and Portland in particular, probably has experienced as much heat pump activity in the past two years as any other section of the United States.

In the commercial field the Equitable Building and the Oregonian Building with their 550-horsepower heat pumps are outstanding. Both installations have been in operation over a year now and the occupants are reported to be enthusiastic. Well water supplies the heat for both of these buildings. Incomplete test data for the Equitable Building indicate that the heating cost is materially less than the $0.46 per million Btu originally estimated.

In addition to these two large installations there have been installed something over 50 Marvair package units by Muncie Gear Works and some 25 Solair package units manufactured locally. Nearly all of the Marvair units have utilized well water as the heat source, and nearly all of the Solair units have used ground coils. The units utilizing the well water have been more troublefree and have presented fewer maintenance and design problems. Units using water operate under steady-state conditions in that well water temperature does not change materially through the season. Units using buried coils as evaporators operate under conditions that are not "steady state." The heat source becomes progressively colder as the heating season advances. This variation in ground temperature causes a corresponding variation in suction and head pressures and temperatures.

Two other heat sources that have been tried in the Oregon area are city water and outside air. Outside air worked satisfactorily down to 37 degrees Fahrenheit at which point the machine was automatically cut over to city water in this particular instance. In the Portland area there appears to be some promise in using outside air as the main heat source with either city water or a relatively small ground coil to carry through the 20-odd days a year when the outside temperature stays consistently below 37 degrees Fahrenheit. The first cost of such an installation is several hundred dollars more than that of heat pump using only one heat source. To date five towns in Oregon have granted permission to circulate city water through a heat pump and return it to the distribution system. Regulation of the use of city water in this manner is entirely under jurisdiction of the local water departments. The important thing is tapping a through main where enough water is being used beyond the connection to assure a continuous supply of warm water. One Oregon unit kept recirculating the same water until ice cubes started coming out of the neighbors' faucets. The other method, whereby city water is taken into the evaporator, chilled, and wasted is all right provided the water temperature remains high enough, and water is not too expensive.

Based on nearly two years' experience the following conclusions are offered:

1. Do not use ground coils if another heat source is available.

2. If ground coils must be used, use only in wet ground, place parallel tubes four to five feet apart and three feet below frost line, design for not more than ten Btu per hour per linear foot of one-half inch outer diameter copper tubing, use at least 600 feet of tubing per compressor horsepower, do not use larger than one-half inch outside diameter tubing, maintain compressor back pressure at 29 to 30 pounds per square inch, design to extract not more than 8,000 Btu per square foot of earth per year.

3. Using water as a heat source requires seven gallons per minute of 50 degrees Fahrenheit water for a 3-horsepower unit and 11 gallons per minute for a 5-horsepower unit.

4. Motors used were 3-horsepower, single-phase, 240-volt, General Electric, type *KCJ*, and 5-horsepower, single-phase, 240-volt, General Electric, type *SCR* or equivalent. Little or no flicker trouble was experienced. Some radio interference from brushes was experienced but was easily corrected.

5. A heat pump should not be installed unless the house is well built and insulated.

6. Application of the residential heat pump is in its infancy and in general is economically justified only on the basis of pride of ownership or the necessity for summer cooling.

7. Annual heat factors in the neighborhood of 0.17 to 0.20 kilowatt-hour per degree day per 1,000 cubic feet have been obtained in the Portland area.

These conclusions are based on experience in an area which accumulates 4,353 degree days annually, has a normal annual rainfall of 41.6 inches and an average wind velocity of 6.8 miles per hour. Average ground water temperature is 52 degrees Fahrenheit. These factors should be given consideration before applying these data to any other area.

Comparison of American and Foreign Practice of High-Voltage Transmission and Generation; *Lloyd F. Hunt* (*Southern California Edison Company, Los Angeles, Calif.*).

In the United States, energy can be transmitted many ways, by fuel pipe lines (liquid and gas), by transportation (railway and ships), and by electric transmission lines. Several fine papers have been written on this subject. The economics in United States allows electric energy to be transmitted up to 200 miles. This is because of the large fuel supply here. If the primitive rule of 1 kv per mile is used, it can be readily seen that 230 kv is the highest voltage that should be used in the United States if the economics rule.

In Europe where the fuel does not exist or is in too small a volume and where a great deal of hydro power can be developed, a higher voltage can be justified economically. In France a large development is being made in the south with the load in the Paris area some 400 to 500 miles away. France has made the technical studies to permit them to go forward on their 400-kv lines. In Switzerland where power has to be transmitted for a similar distance and, perhaps some interconnection, a line is being constructed for 380 kv. Also in Sweden large developments are being made in the northern part with the load some 600 miles to the south. Sweden has taken a conservative attitude in the construction of their 380-kv system.

In order to maintain and to improve on the standard of continuity of service in United States when using voltages higher than 230-kv, it is very important to have system ability to isolate any section of line without dropping load. The higher this voltage the larger the standby reserve which would be required. For instance, if 400-kv line carries 400,000-kw (it should do this to justify its use), it would be very expensive to have 400,000-kw standby from some other source.

In the United States a great deal of maintenance of high-voltage lines has been done with the lines in service. In most countries of Europe it is unlawful to work on energized lines. Therefore, if this is not changed it will require considerably more facilities there to render comparable service.

In high-voltage circuit breakers, the European method of rating is by using the symmetrical rms value of the a-c component of the current that is interrupted. In the United States there is a divided opinion on this matter. It is believed that the European method gives the circuit breaker a more substantial rating. The United States Standard allows the use of the d-c component and a-c decrement in establishing what a circuit breaker has interrupted. The duty on the circuit breaker (especially air circuit breakers) is considerably greater when it is required to interrupt the rated kilovolt-amperes with no d-c component or a-c decrement.

One of the fascinating instruments used in

Europe to check circuit breaker operation is the cathode-ray oscillograph. The Electric of France has several. The one used in checking 230-kv circuit breakers at 6,500,000 kva duty has 15 tubes (12 recording, 3 visual). This gives 12 traces on one recording and has accuracy at very high frequencies.

Electric Space Heating Load Control; *J. C. Beckett (Wesix Electric Heater Company, San Francisco, Calif.).*

Since the start of electric space heating, 30 years ago, the utilities have been afraid of this type of load. Its possible magnitude seemed enormous and the natural human reaction was to avoid the subject. The short duration of the heating season, and the high demands created during this period presented problems of distribution which seemingly could not be met at a rate which was equitable with other classes of domestic service.

At the same time, public desire for the many inherent advantages of electric space heating led to its continued growth in spite of utility resistance and competition of cheap fuels. Efforts to dissuade its use only resulted in much dissatisfaction among all classes of customers.

In recent years, architectural demands, public insistence, and lack of utility control created serious operating problems affecting large areas. Prohibitive rates were hastily passed increasing the strain between customer and distributor without improvement in the load problem.

It was evident that a solution which would permit the use of electric space heating, and which would be equitable to the company and satisfactory to the customer, had to be found. Many suggestions were made, including the heat pump, but none contained sufficient simplicity or were economical for all classes of customer.

The final gap has been bridged with the recent marketing of an automatic regulating device designed to improve the load characteristics of electric space heating. This improvement is accomplished by reducing simultaneous peaks and encouraging continuous operation by the customer. The device accomplishes two purposes—to improve the load, and to give the customer more comfort and convenience. The resulting load characteristic follows more closely the actual heating requirements to maintain 70 degrees Fahrenheit. Greatest demand occurs off system peak and is obtained without the use of clocks or separate meters. With this device demands of the all-electric home seldom exceed 10 kw even with a total connected load of between 40 and 50 kw. Cost of operation to the customer is actually less.

It now appears that this type of load can be served to the mutual benefit of the customer and company by strict observance of two basic essentials, namely:

1. Minimum installed kilowatt capacity through the use of insulation, automatic control for each room, and adherence to sound engineering practice.

2. A load regulating device which will minimize the heat load on residential peak, thereby reducing the requirements for service facilities.

A 120-Volt D-C Multiple Generator Aircraft Electric System; *R. J. Lusk, J. D. Miner (Westinghouse Electric Corporation, Lima, Ohio).*

Since 1943 there has been increasing interest in producing 120-volt d-c systems for large aircraft. Three well-known aircraft, the Martin *Mars*, the Lockheed *Constitution*, and the Hughes *Hercules*, have been provided with such systems. At the present time intensive development work is under way on 120-volt high-power aircraft systems for several new military aircraft.

The control and protective systems presently projected are far more elaborate than those considered adequate during World War II. Overvoltage protection, generator and feeder protection, and co-ordination of protective devices are now available. Effective protection is provided against fire hazards, and continuity of service is maintained under conditions which would have resulted in complete loss of power in older systems.

Normal operation of the system is possible without any attention from members of the crew. Load division is automatically maintained and all normal switching of normal generators on or off the bus as a result of engine speed is fully automatic. Complete protection is provided against the following faults:

1. Grounds or short circuits in generators, feeders, or voltage sensing circuit.

2. Open in voltage sensing circuit regardless of whether generator is switched on or not.

3. Overvoltage or abnormal current division when a generator is attempting to supply overvoltage.

4. Reverse current with loss of sensing to reverse-current relay.

5. Depression of system voltage caused by idling or loss of voltage on one generator.

6. Reset of a fault.

Operation of a single switch resets protective devices after they have tripped. The reset switch and circuit is trip free and cannot be held in on a fault.

The system was designed specifically for use with three 30-kw parallel generators. Maximum short-circuit current to be interrupted was estimated to be 4,000 amperes. Under overvoltage conditions, without protection, potential peak voltage is approximately 600 volts. All equipment is required to operate to altitudes of 50,000 feet.

The control and protective equipment for each generator consists of two basic units:

1. A double line contactor and differential current relay.

2. A base to be installed in the airplane on which is mounted:

(*a*). A shock-mounted plug-in voltage regulator.

(*b*). A shock-mounted subpanel on which are mounted the various control and protective devices.

The voltage regulator is a large, single-stack, carbon-pile regulator having the resistance range of three ohms to 160 ohms. Maximum power dissipation is 300 watts and the weight is 13.5 pounds.

Circuit interruption is accomplished by two contactors in series to provide maximum reliability. A single enclosure for the contactors also includes a differential protection relay which protects the system against grounds in the generators or feeders.

When any of the protective relays operate, a latched-type field relay is tripped. This relay has sufficient interrupting capacity to handle the inductive field circuit at a maximum power of 50 amperes at 60 volts and at any altitude to 50,000 feet.

Especially effective overvoltage protection is provided by means of a new circuit with bias coils in the overvoltage relays. These bias coils are controlled by generator current division and give greatly improved selectivity, making it virtually impossible for any overvoltage condition to cause tripping of normal generators.

Limitation of Ground Faults With Solidly Grounded Neutral; *Martin J. Lantz (Bonneville Power Administration, Portland, Oreg.).*

High-voltage transmission systems in the United States usually are of the solidly grounded transformer neutral type. In modern systems with several large grounded neutral transformers located in one substation, very high concentration of ground currents may result for ground faults. In some cases the current for a single-phase-to-ground fault may be from 25 to 30 per cent greater than it would be for a 3-phase fault at the same point. It may be desirable to limit the ground fault current to the 3-phase value in order to lessen the circuit interruption duty on overstressed oil circuit breakers, especially on existing circuit breakers, lower the station ground voltage rise during faults, or other similar reasons.

Transformers, especially the older ones on grounded systems, usually have graded insulation. Normally the completely graded insulation transformers specify that the neutral must remain solidly grounded and impedors may not be added to the neutral to limit the ground current, since a voltage rise will appear across it during fault.

Proposed in this article is a method to limit the ground current in special cases to the 3-phase value of current without a rise in voltage at the point of neutral connection. This method consists of inserting a center tapped reactor in each corner of the low-voltage transformer delta winding (assuming 3-winding transformer with delta tertiary or autotransformers with a delta tertiary). In order that ground current may flow through the grounded neutral and transformer winding to the line and fault, an equivalent zero-sequence current must circulate in the closed delta winding of the transformer. This circulating current is limited by the added impedance of the three reactors connected in the three corners of the delta winding. The ampere-turns must be balanced between windings of the transformer; therefore the neutral current will be limited as effectively within certain limits as if an impedor were in the neutral. Since the point of neutral connection remains solidly grounded, its voltage to ground cannot change.

This method of neutral current limitation may be applicable to some existing 3-winding transformers with completely graded insulation or to autotransformers where neutral impedors are not recommended.

Expanding the Pacific Coast Telephone Network; *D. I. Cone, C. V. Fowler (The Pacific Telephone and Telegraph Company, San Francisco, Calif.).*

Advances in the art of communication are of commanding importance to the Pacific Coast because of its isolation by mountains, deserts, and oceans, and great strides have been made in telephony since 1915 when transcontinental service was first established.

During this period of expansion, the Pacific Coast area has increased three-fold in population, seven-fold in telephones, and 30-fold in telephone toll-circuit mileage. New developments in multiplexing by carrier systems on wire lines, cables, coaxials, and radio systems also have been accompanied by the advent of radio program broadcasting, telephoto, new telegraph services, and radiotelephone connection to points overseas as well as locally, on land, for both fixed and mobile services.

Application of the new methods has made it practicable to meet the soaring demands for telephone communication. As terminating equipment has become more complex, the intermediate line structures have decreased until in the microwave radio channels now in use and projected, the only requirement between stations tens of miles apart is a line-of-sight pathway. Flexibility and dependability have been greatly increased and new areas served by multiplying routes, in contrast with the single-route layout of 1915.

Prior to 1930 the growth of facilities was characterized by the use of voice-frequency cable circuits and by open-wire telephone lines with 1- and 3-channel carrier systems. The activity of research and development engineers during the subsequent decade made ready entirely new carrier systems, using existing lines and cables so effectively that requirements for vital materials were greatly lessened. These developments have been instrumental in meeting the great demand for telephone service which began ten years ago.

For example, cable-carrier 12-channel systems now provide 1,600 route miles and 740,000 telephone circuit miles, including the western portion of the initial transcontinental cable. Open-wire 12-channel carrier systems furnish 202,000 circuit miles on 4,200 route miles. A coaxial route connecting Los Angeles with eastern points in 1947 and Sacramento with Portland in 1948 already adds 860 route miles and 294,000 circuit-miles with large capacity for expansion. These coaxials may be equipped, of course, for television.

A radio relay system to provide television channels and hundreds of message telephone circuits between Los Angeles and San Francisco, as required, is under construction with initial operation scheduled in 1950. This will utilize four million kilocycle equipment developed out of experience with the New York–Boston microwave system. Microwave systems of one and two links and eight and 16 channels already have given satisfactory communication service in California.

Along with the multiplication of communication paths between communities has come toll dialing—a machine method for interconnecting these paths. This is a major contribution to giving faster, more accurate, and more dependable long distance service to its customers.

Scores of communities have been furnished local telephone service for years through local dial offices. Gradually the range of the dial mechanism has been extended until operators were able to dial nearby towns. On the Pacific Coast these short-haul dial systems center around Seattle, Portland, San Francisco, Oakland, Los Angeles, San Diego, and several inland cities.

Recent developments have removed distance limitations on operator toll dialing. These included improved toll switching arrangements employing crossbar equipment and associated long distance dial impulsing and supervision arrangements. The first installation on the Pacific Coast will be completed at Oakland this fall. Other similar installations have been made at Philadelphia, New York, and Chicago. This represents the start of a nationwide toll dialing system.

To harness these developments to the service of a rapidly growing region has required large amounts of capital. This process must continue if the communication art is to keep pace with the needs of its customers and only by such technological strides as those described can these needs be met at bearable cost.

Sound-Powered Telephone Systems; *Alvin P. Egerman* (*San Francisco Naval Shipyard, San Francisco, Calif.*).

The sound-powered telephone is assuming a more important role in the communication systems used throughout the world. The purpose of the sound-powered telephone is to provide a rapid and efficient means of transmitting and receiving verbal orders and information to and from any desired number of stations. It is most widely used in linking together the fighting and manuevering units of ships large and small. United States Naval vessels make extensive use of sound-powered telephone systems in solving their many intricate communication problems.

A sound-powered telephone is exactly what the name suggests—a telephone system in which the power comes from the sound of the voice. Sound vibrations from the voice strike the diaphragm (a very thin metal disk) in the mouthpiece of the transmitter, causing the diaphragm to vibrate. A very delicate needle called the armature is attached to the inside of the diaphragm. Surrounding this needle is a coil of very fine wire which is held in place by a permanent magnet. Each time the diaphragm vibrates from voice sounds, the armature also moves inside the coil. This creates a current in the coil which flows through wires to the earpiece of the receiver. The construction of the earpiece is similar to the mouthpiece. Thus the current flowing from the mouthpiece to the earpiece causes the armature and diaphragm in the earpiece to vibrate in unison with the transmitter and the message is heard at the receiver.

Sound-powered telephones are moisture-proofed and will withstand immersion without damage to the mechanism. These telephones are designed to operate efficiently under most conditions encountered in marine practice, even under pressures varying widely from atmospheric pressure.

In conclusion, it is interesting to note that sound-powered telephones are now in mass production for general public distribution. It has been established that these telephones will give satisfactory operation for distances up to 25 miles. In rural areas where a power supply is uncertain or unavailable the sound-powered telephone is definitely coming into its own. With the recent development of a self-powered ringing system the use of sound-powered equipment in industry and mercantile applications undoubtedly will be widespread.

Design of 120-Volt D-C Aircraft Generators; *A. Fisher* (*General Electric Company, Schenectady, N. Y.*).

The increase in electric load on present-day aircraft necessitates the adoption of higher voltage d-c or a-c generators. System studies have indicated that the weight of cables, generators, and control devices establish the size of variable speed, directly connected engine-driven 30-volt d-c aircraft generators to a practical limit of 400 amperes and a ceiling of 600 amperes. Generator design limitations such as commutator dimensions, brush current densities and losses, peripheral speeds, and weights, indicate similar ampere limitations. The design of systems is necessarily dependent on the design limitations of the generator and it is essential for the system designer to know just what the generator designer can do for him.

The purpose of the paper is to point out some of the design possibilities for higher voltage d-c generators and to describe in greater detail, the design features of the 120-volt generator, now in use or under development.

Successful 120-volt wide-speed-range generators with ratings up to 30 kw, 3,000/8,000 rpm have been built and ratings up to 50 kw have been designed.

Flexural Vibration in Aircraft Engine Accessories; *I. Kalikow* (*General Electric Company, Schenectady, N. Y.*).

Most aircraft engine parts, and especially aircraft engine accessories, operate under conditions of forced vibration. That is, the part or accessory is forced to vibrate at a frequency other than its natural frequency. These systems for the most part can be studied as systems of one degree of freedom.

Various types of engines have differing forcing frequencies at the accessory mounting pad. It is essential that these be known for design safety. A method is given for applying known engine vibration amplitudes and frequencies, so as to achieve maximum safety of accessories. The method chiefly relates to choosing correct mounting stiffnesses, with respect to the weight to be carried, the amplitudes of the forcing vibrations, and their frequencies.

An important phase of design is adequate laboratory testing of proposed accessories. One of the best and simplest means of testing the adequacy of a design is to test it at its natural or critical frequency. Also, it preferably should be tested on a relatively stiff structure so as to provide a test factor of safety over the actual engine installation. Laboratory facilities may be easily set up using magnetic oscillations to provide enough driving energy to test most present-day accessory designs.

A Modern Air Transport Generator Protection System; *Cesar A. Tolivar* (*Lockheed Aircraft Corporation, Burbank, Calif.*).

A new generator control system providing a high degree of protection against generator overvoltage, undervoltage, and feeder-faults has been adopted as standard for all Lockheed *Constellations*. The system was developed by Lockheed, with the co-operation of Hartman Electrical Manufacturing Company and the General Electric Company, and was tested in a 4-generator mockup under

all conceivable conditions before being put into production.

The high-capacity wide-speed-range generators now in general use have presented new problems in system protection. Overvoltage of five to seven times normal can result from troubles in the shunt field circuit.

Some degree of protection has been provided in the past by thermal or magnetic circuit breakers in the shunt field circuit or by a voltage sensitive relay across the shunt field. These are of limited value since dangerous over voltage can be experienced with out exceeding rated field current and voltage.

The overvoltage portion of this new system operates on bus voltage. Its operation is independent of generator speedload conditions, always tripping on 30 volts at the relay. The trip time has been set at the minimum consistent with ability to over-ride system transients. One hundred per cent effectiveness in disconnecting of the proper generator has been achieved by the use of polarized selector relays in the equalizer circuits which by-pass all overvoltage relays except the one on the generator producing the overvoltage.

Protection against reduced bus voltage due to equalizer action when a generator is disconnected because of reduced speed, is provided by opening the equalizer circuit under this condition.

While much effort has been expended on protection of systems beyond the central bus, very little has been done on protection of the generator feeders. The reverse current relay offers little protection; since even if it opens the generator still feeds the fault. The reverse current circuit breaker, which opens the generator shunt field as well as the feeder at the bus, is effective in clearing the fault only if the fault is of sufficient magnitude to open the circuit breaker before the reverse current relay.

The new system detects a fault by comparing the current in the series field of the generator with the current entering the central bus. If these are substantially different the feeder is isolated by disconnecting it at the central bus and by opening the field circuit through a multipole relay.

These developments give the *Constellation* the most advanced generator system in production today.

Steel and Electricity in Partnership; *George L. Beaver (General Electric Company, San Francisco, Calif.).*

To serve Western markets for tinplate and other flat rolled steel products, Columbia Steel Company has provided complete modern cold reduction and cold finishing facilities at its Pittsburg, Calif., works. Such facilities must be supplied with hot rolled coils, which are produced with a continuous hot metal rolling mill. Cold processing should be regarded as the final part of an integrated operation; the initial stages of such operation may occur in the same or in another steel plant. In this instance, Pittsburg Works will be supplied ultimately with the needed hot rolled coils, produced at Geneva, Utah, in the mills of Columbia Steel's sister United States Steel Corporation subsidiary.

Before the thickness of the hot rolled coils received is reduced by cold rolling, scale and rust is removed with acid, and the material is washed, dried, and coated with palm oil. This is all done in one type of "processing line," known as a "pickling line." The material is then "cold-rolled" in a 56-inch 5-stand tandem cold reduction mill, which produces either sheet or tinplate gauges.

Cold reduced coils from the tandem mill then are cleaned in either one or the other of two continuous electrolytic cleaning lines; here, oil and foreign substances, accumulated during rolling and previous processing, are removed. The recoiled product from these cleaning lines is then annealed in large furnaces.

After annealing, the coils are given a final rolling, to bring the material to exact gauges, and to impart the proper temper and finish, in "temper mills." From these mills, the coils are taken to various processing lines, where the continuous coiled lengths are sheared into flat pieces of limited length, for shipment to the market. In addition to the production of black sheet, equipment is provided for the production of galvanized sheet and both hot-dipped and electrolytic tinplate.

The 5-stand tandem mill is the major production unit. Each of the five mill stands and the related winding reel is separately driven by a 600-volt d-c motor; these motors vary in size from 800 horsepower to 4,000 horsepower. Each one of these large motors is supplied from a separate generator. These large generators are grouped in two motor generator sets, which are driven by 6,600-volt 3-phase 60-cycle synchronous motors. One synchronous motor is rated 6,600 horsepower and the other 13,300 horsepower. This relatively new use of separate generators simplifies the required heavy bus work, and increases the flexibility of mill performance.

The tandem mill control apparatus is especially designed to control all six main drive motors and generators, and the mill, as a co-ordinated unit. The cold rolling method depends upon both "squeezing" the product, as it passes between closely-spaced power driven rolls, and "pulling" the product, between the mill stands, by establishing and maintaining a controlled "tension." This fundamental requirement calls for most exacting and complicated control apparatus.

Each "processing line" section, may be powered by one or more motors; these may be a-c or d-c type; d-c motors may be "adjustable speed," by "field weakening" and supplied from the 250-volt d-c general-purpose power system, or speed adjustment may be obtained through adjustable voltage control by means of special-purpose motor-driven generators. Electrically operated valves, solenoids, welders, stitchers, electrolytic and heater circuits, and so on, may form parts of a given processing line.

Each processing line requires a special purpose, completely co-ordinated control installation. Instruments, switches, rheostats, and devices requiring access for operating the line, are located on control desks, on the mill floor. Related control panels are installed elsewhere.

Primary power is supplied throughout the mill area, at 6,900 volts, 3 phases, 60 cycles; this is obtained from the 117,500-volt system of the utility company serving the area, through a 30,000/40,000-kva capacity substation; 60 cycles, 3 phase, power for various incidental uses, at 2,400 volts, 480 volts, and 120/208 volts, is supplied from the 6,900-volt system, through load center units and small substations. A general-purpose 250-volt d-c system is supplied from the 6,900-volt system, through pumped-type ignitron rectifiers.

There are many interesting, specialized equipment applications, for battery charging, electric haulage, material handling, electronic control, electric heating, electric welding, electrolytic processing, and for conversion of alternating to direct current.

Philosophy of Protection of Aircraft Electric Systems; *Lee R. Larson (Naval Research Laboratory, Washington, D. C.).*

The protection of electric systems has been applied mainly for the prevention of damage to electric equipment due to overheating or overstressing the components. Normal industrial installations result in a system that, in protecting itself, gives adequate protection to surrounding equipment. Unfortunately, this philosophy has been carried over into aircraft installations without serious reservation.

Two types of faults are encountered; namely, welded or solid faults and arcing faults. The first is characterized by high sustained currents with damage to the electric system. The second is characterized by intermittent flow of current with damage to the surrounding structure. In general, available protective devices adequately clear welded faults and will not be discussed.

Laboratory investigations of d-c systems using simulated environmental conditions of vibration, atmospheric pressure, and temperature have shown that arcing faults can cause excessive damage to the surrounding structure. For cable sizes ranging from *AN 18* to *1/0* the average current to the fault was found to be essentially constant ranging from 10 to 20 amperes for 30-volt systems. Oscillographic records show the peak currents to range from about 40 to 400 amperes depending on the circuit resistance and the condition of the arc.

As the system voltage is increased to 120 volts, two distinct changes are noted. The arc becomes more violent and tends to be continuous rather than intermittent. By limiting the peak current with resistance, it has been found that arcs can be sustained at less than five amperes for a period of several minutes.

The mechanism of an arcing fault results in high temperature being produced in the arc volume and heat being conducted into the cable along the conductor. The resulting temperatures cause the normal aircraft cable insulation to burn intensely. The burned insulation is a thin brittle residue covering the conductor. In the presence of vibration, the residue tends to chip away gradually feeding the conductor into the fault. This action reduces the possibility of establishing a welded fault.

The following conclusions are based on laboratory investigations:

1. Arcing faults may not overload the individual circuit.
2. Structural damage and fire hazard due to arcing faults may be extensive.
3. Differential cable protection based on welded fault conditions is not adequate.
4. Adequate system protecton for a grounded system will be prohibitive from the weight standpoint.
5. An ungrounded system with a fault sensing device will greatly reduce the problem of fault.

A New Approach to an Aircraft Electric System; *E. F. Kotnik (Consolidated Vultee Aircraft Corporation, San Diego, Calif.).*

The objectives to be accomplished by the modern flying boat type of aircraft require the use of the most recently developed electronic and armament equipment. The operational requirements of this equipment lead to electric loads of greater magnitude than theretofore accumulated on aircraft electric systems.

The limitations of engine pad available area and overhanging moment require the investigation of the use of remotely driven generating equipment. Another factor, namely, engine starting of the turbo-prop and turbo-jet-type modern engines imposes power requirements far in excess of conventional starting methods.

Turbine engine design specifications require the availability of compressor bleed. This requirement lends itself to the design of a low-pressure pneumatic system which provides a source of energy for remotely driven generators.

The installation of auxiliary gas turbine compressors in the aircraft provides air to the engine air turbine starters as well as to remotely mounted air-turbine-driven generators. This system is unique in that it utilizes the same manifold for compressed air supply in flight as well as at anchor. A further simplification and weight saving is accomplished by the fact that the same generating equipment is utilized in flight and at anchor.

The temperatures, pressures, and weight flow of the afore-mentioned air enable its use for cabin heating, wing anti-icing augmentation, and ground oil cooling augmentation.

In view of the foregoing, it is obvious that each functional item of equipment must be evaluated on the basis of the objectives of the entire aircraft. Only by adherence to this principle will it be possible to continue to improve the over-all efficiency of modern aircraft.

Topographic Presentation Radar; *W. J. Hirschberg (California Institute of Technology, Pasadena, Calif.).*

Present area scanning radars use a beam parallel to the earth's surface to present the familiar PPI picture. Although such a picture shows the boundaries of shore lines, buildings, or mountain ridges, it yields no information as to the height of the objects sighted.

The topographic presentation radar is used aboard an airplane and produces on a cathode-ray tube screen or on a photographic film a 3-dimensional picture of the terrain below. The third dimension is obtained by modulating the *Z*-axis of the scope, that is, intensity on the scope will represent height on the ground.

A sharp, pulsed radar beam is sent vertically downward and is made to scan the ground at right angles to the direction of motion of the airplane. Combining this with the forward motion of the airplane, a continuously advancing band of terrain is being scanned. Simultaneously, a television-type scanning takes place on the scope in synchronism with the scanning on the ground.

The intensity modulation is achieved as follows: A special wave form, called the contrast saw-tooth wave form, is generated in the radar receiver. The saw-tooth parts from its minimum to its maximum value in a fraction of the pulse period of the radar and is automatically positioned (in time) with respect to the transmitter pulse in such a way that an average altitude echo pulse will return when the saw-tooth has reached half its maximum. All echo pulses are superimposed on this saw-tooth, so that the peak value of the resultant wave form changes with the instantaneous position of the echo pulse. This peak value then modulates the grid of the cathode-ray tube.

The monitor scope should have a persistency high enough to allow a complete picture to be formed, but not high enough to interfere with the following picture.

For the purpose of producing an accurate record of the terrain a continuously moving photographic film is used. Since the average altitude of the airplane over the terrain will show up as grey in the picture, all other altitude values will be relative to the average. The radar however furnishes separately the value of this average altitude at any instant. This combined with the absolute altitude above sea level, obtained from barometric instruments, furnishes the absolute altitude of those points on the map, which are halfway between black and white. This reference level can be continuously recorded together with the map itself thus allowing an accurate evaluation of the record.

Special circuits are included which provide for a constant scale factor in the x and y directions no matter what the altitude of the airplane. Maps thus could be made directly from the photographic record. As a matter of fact, the rapid, accurate production of maps of unknown territory is the ideal application of this radar device. One even might dream of the exploration of the moon from aboard a rocket.

Design of a Tit-Tat-Toe Machine; *Robert Haufe (California Institute of Technology, Pasadena, Calif.).*

Many common games can be analyzed from a consideration of the rules and objectives of the game, and on the basis of this analysis some sort of rational system for playing the game can be evolved. Once one has such a system at hand, the problem of building a machine to play the game against a human opponent becomes a technical one.

This paper describes the analysis of the game of Tit-Tat-Toe and the design of a machine to play it. This game was selected because it is universally familiar, being played in nearly every part of the world. The game consists of two players alternately placing markers (usually *X* and *O*) in a field of nine squares, formed by two vertical and two horizontal lines. The game is won by a player if he is able to get three of his markers in a straight line.

The purpose of this machine is to alternate with a human player in filling the squares of an indicating device in the form of a Tit-Tat-Toe board. The machine consists of a number of relays and their associated equipment, among whose functions is to keep a record of which squares are filled by each party, to cause the machine to make a rational move each time it has its turn, and to determine the result of the game when it is finished.

The nature of the circuits is such that, each time the machine has its turn, all of the squares, whether they have been filled or not, are classified in order of decreasing strategic desirability; another circuit then investigates these classes successively until it finds a square which is empty. The machine then is caused to take this square. Auxiliary circuits perform other functions, such as preventing the human player from taking more than one square at each turn, preventing further play after the game has been won, and restoring the relays to their initial state at the beginning of each new game.

The strategy incorporated into the machine is such that under any ordinary circumstances the machine either will win or force the human player to a draw. In order to make the game more interesting, however, a switch has been built into the machine, which, when thrown, permits a skillful player to win.

Despite the fact that this machine will play hundreds of different games without losing (except as noted in the foregoing), and that it is protected against attempts to cheat it, the circuit requires only 32 relays, including a 20-position rotary step relay. Using conventional telephone-type relays, the machine can be operated at such a rate that it needs but two seconds to complete each move.

An Electronic Fluxmeter; *P. B. Gallagher (University of Santa Clara, Santa Clara, Calif.).*

Out of the need for an instrument with which to measure the voltage outputs at points along a magnetic tape was developed the idea for an electronic fluxmeter. The instrument described herein is designed with the flexibility and accuracy as to be able to measure magnetic fields (magnitude and direction) ranging in values of flux density from 100 lines per square inch to 100,000 lines per square inch, with allowable space variation in intensity over a linear inch of 500 cycles.

A 60-cycle power source operates both the detector unit and synchronization of the multivibrator, of free running type. The multivibrator output consists of negative 15-microsecond square topped pulses at 20 cycles per second. The width of the negative pulse is adjustable from 2 to 15 microseconds via the pulse width adjust network, such a range being necessary for maximum sensitivity and accuracy. The pulse is inverted in the amplifier stage, which is a 2-stage voltage amplifier having two inputs—one is the signal from the detector, the other the positive pulse from the multivibrator, which is applied to the cathode of the second stage to act as an enabling pulse. The signal from the detector may pass on through to the indicator unit only during the 2-15-microsecond pulse period. The output of the amplifier then will be a positive or negative (depending on the direction of the field) pulse of amplitude that is proportional to only the amplitude output of the detector signal at that instant. The indicator may be a calibrated peak-indicating vacuum tube voltmeter, or an oscilloscope.

The heart of the system, the detector, consists of a nonmetallic casing which encloses a small synchronous clock motor, which drives the shaft of the detector coil at 1,200 rpm. The shaft is also of nonmagnetic material to avoid upsetting the external field, and has mounted upon its right end a small rectangular doughnut-shaped coil of copper wire 3/8 inch by 1/4 inch. Two leads from

the coil run down the hollowed center of the rotating shaft to the primary of a "rotary transformer," which transfers the signal from the coil to the external circuit. Its cross section is also a square doughnut shape.

Theoretically the detector embodies very fundamental principles, in that it consists merely of a small generator (coil) whose current output is transferred to the external circuit by generator action. Each time the rotating coil is in the position (every 1/20 second, so that the rotating transformer winding is face to face with the stationary winding, maximum voltage is induced into the transformer secondary by generator action. The 2–15 microsecond pulse output of the pulse generator is made to act during this time. The angle of travel of the transformer primary during this 2-microsecond period has been calculated to be about 0.08 degree, hence coupling of the signal in the rotary transformer during this time may be assumed constant. The secondary signal voltage is then proportional to the instantaneous primary transformer current, and consequently the indicator reading is directly proportional to the flux density of the field being traversed during this 2–15-microsecond interval. The position of the rotating coil is known at this time, in virtue of the fact that the 2-microsecond pulse is made to occur once per revolution of the coil, and at the position of the coil as stated in the foregoing.

A Phase Adapter for Aircraft and Other Applications; *F. W. Maxstadt* (*California Institute of Technology, Pasadena, Calif.*).

The need for a converting device that will, without moving parts, change an a-c supply from single- to three-phase is real but not extensive. Approximations have been available in the form of series capacitance and inductance to obtain the third terminal. Such a circuit carries a considerable current other than the load current and is, in consequence, wasteful of energy as well as apparatus capacity.

A new circuit is proposed in which the phase shift of a quarter cycle in the voltage with respect to the current in a capacitor is utilized along with the load power factor to produce a leading or lagging phase shift of voltage of 120 degrees with respect to the single-phase supply, thus completing the desired three phases. The same type of circuit is used by suitable polarity and voltage proportioning to produce 120 degrees lead on the one hand and duplicated with other proportions and polarity to produce 120 degrees lag on the other. Voltage proportions to suit the load are secured by transformation ratios which also reduce capacitor currents and thus provide more favorable capacitor sizes.

The load current is the only current in the transformer secondaries. With proper design the ratio current is the chief current in the primaries. Theoretically the device is operable at only one load for a given adjustment. Furthermore, it can be economically adjusted for load power factors between 0.3 and 0.7 lagging only. While the foregoing limitations seem narrow, the present demand for small static phase converters falls within that range. Various dodges such as power factor correction by means of capacitors in the ordinary way can be used on loads of power factor lower than 0.3 while magnetizing currents of suitable magnitude in the transformers included in the device can be used to help lower power factors above 0.7.

Suggestions for modification of the theoretical design would provide a more practical unit in which a saving of capacitor size is achieved together with an expansion of the load range for a given adjustment. Experience shows that induction motors can be started and operated at full load without changing the unit. It is, however, warned that operation of the device without load is unsatisfactory.

The circuit is fundamental and the maximum rating of the device that can be built is unlimited, except by economic considerations. The efficiency is high because only the useful load current is carried by the circuit elements involved, unless compromises are utilized to achieve some particular qualities such as extended load range. Even then the extra losses are not serious. Just as with transformers and capacitors, sizes are reduced by increasing system frequency. Therefore, the phase adapter will be very much smaller for operation on 400 cycles than on 60 cycles. It is especially recommended for use on single-phase aircraft electric systems. In some applications it probably can be used with 3-phase 60-cycle induction motors in competition with the 2-phase capacitor-start motors now popular. Motor size could be reduced 30 per cent or more by its use.

A 250-volt-ampere unit for operation at 115 volts, 400 cycles, is only three inches by four inches by six inches and has losses so small that no ventilation other than the natural cooling of the surface of the sealed can is required. It weighs only four pounds.

When designed for a narrow load range at constant frequency and power factor suitable for supplying fractional horsepower induction motors the proposed phase adapter has advantages in efficiency, space, and weight over the usual phase splitting circuit. It has the disadvantage of requiring the stabilizing effect of a load and should be switched on and off with its load.

University of California Proton Synchrotron (Bevatron); *George M. Farly* (*University of California, Radiation Laboratory, Berkeley, Calif.*).

The proton accelerator now under construction at the University of California Radiation Laboratory will make available nuclear particles with kinetic energies in the range exceeding one bev (billion electron volts). This is the reason why the name Bevatron has been chosen for the University of California machine.

The principal limitation in the energy attainable in this type of accelerator lies in the size and cost of the electromagnet and of the magnet power supply. The magnetic field must be pulsed for each acceleration cycle. During each pulse the magnetic field will absorb 80,000 kilowatt-seconds of energy from the power supply and the peak power demand from the supply will be 100,000 kw. Most of this energy will be returned to the supply after each pulse and stored as kinetic energy in rotating flywheels. The cycle will be repeated ten times per minute.

Two motor-flywheel-alternator sets will be required for the magnet supply. Each alternator is built with four separate star-connected 3-phase windings which are displaced to be equivalent to a 12-phase machine. Each winding will be connected to a group of six ignitron rectifiers having a common cathode connection. The ignitrons can be excited by suitably phased signals to operate as rectifiers when energy flow is from flywheel to magnet, or as inverters when energy flow is from magnet to flywheel. Any net loss of energy will be supplied from the Pacific Gas and Electric system via wound-rotor induction motors.

The magnet will be arranged in four 90-degree quadrants connected by straight sections containing no magnetic field. A continuous vacuum chamber will link all sections and define the channel in which particles must be guided during the acceleration.

Protons will be injected into the vacuum chamber with an initial velocity appropriate to the strength of the magnetic field at the instant of injection. Almost simultaneously an electric accelerating section will be energized and some protons will pull into step with the electric accelerator. From then on, if the frequency of the oscillator is programmed according to the strength of the magnetic field it will be possible to accelerate particles to an energy corresponding to the peak value of the magnetic field and the radius of curvature of the accelerator. For 50-foot radius of curvature and 16 kilogauss the corresponding proton energy is 6.4 billion electron volts. The protons will travel about 300,000 miles during the 1.85-second acceleration interval.

An experimental quarter scale accelerator is now operating and protons have been injected at 0.7 million electron volts and accelerated to 6.5 million electron volts. The machine is providing valuable information regarding injection problems, scattering losses, and the effect of aperture dimensions on beam intensity. The aperture dimensions that will permit magnetic field intensities of 16 kilogauss to be attained are one foot high by four feet wide. Model test will reveal the critical factors such as frequency tracking, vacuum conditions, and injection energy, which will be necessary to insure a significant intensity of six billion electron volts protons when the Bevatron is completed.

This work was done under the auspices of the Atomic Energy Commission.

The Stanford Linear Accelerator; *Richard F. Post* (*Stanford University, Calif.*).

An electron linear accelerator designed to attain one billion electron volt energies or greater is under construction at Stanford University. The design is based on work done by W. W. Hansen, who directed the program until his recent death.

At low energies, the electron acts as a work horse for the electrical engineer. At high energies it becomes a promising research too for the physicist. Circular accelerators, such as the synchrotron, have produced electrons with energies in excess of 300 million volts. Such machines, however, are not considered practical for energies greater than about one billion electron volts. This is because of large energy losses through radiation which are suffered by high-energy electrons when moving in circular orbits. Radiation effects are negligible in linear machines, and there is in principle no limit to the energies which can be obtained. Paradoxically, through the dominance of relativistic effects at high energies, when the electrons are moving at almost the velocity of

light, many of the design problems become much simpler.

The Stanford linear accelerator will consist of an evacuated wave guide, 160 feet long, periodically "loaded" with irises in such a way that microwave energy injected into the guide moves down it with a wave velocity nearly equal to the velocity of light. Electrons injected with the correct energy and phase ride the crest of the wave and increase their energy at a rate of about six million volts per foot. In order to obtain sufficiently strong wave fields moving at exactly the right velocity it has been necessary to devise many special techniques for the construction and adjustment of the accelerator tube, and to develop higher power sources of microwave energy than have heretofore been available. These high power sources have taken the form of klystron power amplifiers, one of which will be used for every ten feet of accelerator tube. All of the amplifiers will be driven at a controlled frequency and phase from a single stabilized source.

The theory of operation of the accelerator has been amply borne out by the performance of a small six million electron volt model, in operation for more than a year. A 15-foot prototype section of the 160-foot accelerator has been constructed and is in the process of being tested. The prototype should yield 70 to 80 million electron volts, and its operation will give a representative picture of the expected performance of the 160-foot model.

When the physicist has available electrons of energy of one billion electron volts or greater he will have a powerful research tool capable of duplicating in the laboratory many of the phenomena heretofore only hinted at by cosmic ray experiments.

The accelerator project is supported by the Office of Naval Research, contract number N6-ONR-25116.

The Outlook for the Nuclear Power Plant; *I. Perlman (University of California, Berkeley, Calif.).*

The development of nuclear reactors for the generation of useful power should be considered an experiment which must be made. The number of unknowns still in the picture make it impossible to predict the exact time or manner in which this new form of power will become an important adjunct to the world's power resources. Present indications are that the task of building a nuclear power plant is an extremely difficult one. If unforseen obstacles should complicate the design further and render the construction and operation more difficult and expensive, atomic power could be a generation away. If, after building an experimental unit, it is found that conservative estimates of performance are exceeded and that important short cuts may be taken, then atomic power for special uses could arrive much sooner.

The problems in engineering, chemistry, and physics probably should be ranked in that order with regard to difficulty. Underlying all aspects of a nuclear power plant are the extreme precautions that must be taken to assure that there be no uncontrolled escape of dangerous radioactive substances and that structural components that become radioactive either last for an acceptable plant life time or be made susceptible to replacement by remote control. The selection of a high-temperature coolant is another important problem. All components of a power unit not only must pass these stringent structural requirements, but they also must have the property of absorbing a minimum number of neutrons, a strictly nuclear property having nothing to do with any of the atomic properties such as physical strength and chemical reactivity. This requirement eliminates many of the common materials which would otherwise be usable.

Chemical problems of some magnitude lie in the recovery of fissionable material from partially burned out fuel elements. The U^{233} or Pu^{239} which will be the active components of the fuel elements will have to be reprocessed at intervals to remove accumulated wastes. The more frequently this will have to be done, the greater will the chemical recovery process be taxed because economy of the plant will depend upon the amount of fissionable material which can be burned for power and therefore not lost in successive recoveries.

There is an extremely important problem in physics whose outcome will make a great difference in the feasibility of industrial power. This has to do with the principle of "breeding" or converting the bulk of non-fissionable U^{238} into a fissionable form, namely Pu^{239}. It seems possible in a properly designed reactor to not only sustain a chain reaction but at the same time to produce more fissionable material than is used. This principle of "breeding" immediately affords the possibility of utilizing all of natural uranium instead of the minor constituent U^{235} an increase by 100-fold in the power output of natural uranium. If usable, this method of operation also would make thorium a nuclear fuel.

It should be emphasized that it would be possible and relatively easy to demonstrate nuclear power by sacrificing some objectives which will ultimately need to be reached. One could obviate many of the technical difficulties by operating at a fairly low temperature, the chemical problems by neglecting the recovery of the unburned fuel, and the most important physics problem by neglecting breeding. It is probably among the power reactors now under development that attempts are being made to solve all of these difficult problems which ultimately will make the difference between success and failure of the nuclear power program.

Radiac Instruments; *Clarence F. Parker (San Francisco, Calif.).*

The wartime dangers and the peacetime opportunities which are presented by the development of atomic energy have proved a strong impetus to the development of radioactivity detecting instruments. The uses of such instruments run the gamut from locating lost radium and prospecting for uranium, to the survey of radioactive areas in the vicinity of a nuclear bomb blast. It is natural that the representatives of the National Military Establishment should be most interested in the tactical use of radioactivity detection as exemplified by the latter. In particular, the Navy has proceeded with a definite program of research through the Navy Radiological Defense Laboratory in co-operation with the Bureau of Ships which has been termed "RADIAC" (Radioactivity Detection, Identification, and Computation).

The forms of Radiac instruments are as widely varying as the uses to which they may be put, ranging from pocket-size dosimeters to bulky, complex alpha counters. But despite the wide range in size and complexity, there is a certain similarity between all such instruments. As an introduction, the means of detection and the particles of radiation will be reviewed, followed by a brief description of a widely used survey meter, *AN/PDR-7*.

Radiation is detected by ionization. In this instance the rays or particles of radiation ionize the gas within a detecting tube. The tube, in turn, is subjected to a high-potential electrostatic field from an external battery. The resultant movement of the ions within the tube produces a voltage drop across an external series resistor and, hence, gives an indication of the presence of radiation. The potential impressed upon the electrodes is critical; that is, there is a certain threshold above which current flow is made continuous by secondary ionization effects. Just below this threshold occurs the "Geiger region" which has been found to be the optimum point of operation. In the Geiger region, partial secondary ionization increases the number of ions formed from a single particle of radiation, resulting in an avalanche of ions from each ionization event.

Radioactive material, natural or artificial, is the source of the three types of radiation to be detected: alpha particles, beta particles, and gamma rays. Because of their greater range, gamma rays are the radiation for which most of the survey meters are designed. Gamma rays are ultrashort electromagnetic waves very similar to X rays, and like the latter, pass easily through most materials. Beta particles are simply high-speed electrons and are termed "hard" or "soft" according to the velocity at which they are emitted.

A representative radiation detector used by the Navy is the *AN/PDR-7*. This is a counting-rate meter which gives a measure of the intensity of gamma and/or beta-gamma radiation by the amplification and integration of impulses from a Geiger-Mueller detecting tube. This tube is housed in a perforated metal case for protection and has a sliding brass shield for the purpose of differentiation between gamma and beta-gamma radiation.

Other radiation detectors may take the form of counters, which record each impulse over a period of time, or dosimeters, which measure the dissipation of an electrostatic charge. In any case, the three principles to be remembered are: First, detection is effected by the ionizing properties of radiation; second, radiation may be thought of as particles or waves of widely varying ionizing properties; and third, the radiation detector as a whole must be designed for a specific function although all such instruments have a fundamental similarity.

Tests of Load Interrupter Switches for 115-Kv Service; *O. A. Demuth, H. L. Rorden (Bonneville Power Administration, Portland, Oreg.).*

In the area of the Northwest served by the Bonneville Power Administration transmission system the hydrogeneration is remote from many of the load centers. It is necessary to transmit the power at relatively high voltage over these long distances to reach the few major load centers and the in-

creasing number of smaller localized centers. The major network consists of over 1,400 circuit miles of 230-kv transmission lines. A secondary transmission system, including more than 1,600 circuit miles of 115-kv transmission lines, distributes the power to the localized smaller load areas. On the 115-kv network there are some 40 substations in operation, with many more under construction. The greater portion of these have capacities of 6,000 kva and less. As the secondary system expands with an increasing number of the small localized loads, it has been found necessary to serve such loads by an increasing number of small substations. This can be done economically only by careful co-ordination and selection of equipment.

Transformation is an obvious necessity and requires either a considerable network of a still lower voltage subtransmission system, or a multiplicity of small stations tapping into the 115-kv grid stepping down directly to distribution voltages. The latter method has been deemed to be the more practical solution, assuming that it is possible to obtain suitable switching equipment at a reasonable cost. Transformation from 115 kv for relatively small loads of itself is expensive. Associated equipment required for switching and protection can easily so overburden the initial cost as to make the installation impractical. The questions of transformation, switching, and protection were, therefore, subjects of study to determine if costs could be reduced.

Among the expensive accessories of transformers are oil circuit breakers. For many small loads, fuses with air-break switches can be substituted. The difference in cost makes this substitution a necessity, although fuses have some obvious undesirable features. A transmission network which includes tapped lines offers several applications for switching, for which conventional oil circuit breakers cannot be justified economically and for which fuses are undesirable. Due to the rapid growth of power systems, the capacity of conventional oil circuit breakers has been increasing, and now leaves a gap between oil circuit breaker ratings and the maximum capacity of fuse and air disconnecting switches. There is, therefore, a necessity for switching equipment for small loads at relatively high voltages.

In an attempt to obtain a low-cost switch, the Bonneville Power Administration submitted invitations to supply, and to cooperate in conducting staged tests of switches designed for this purpose. The request specified a 115-kv switch capable of interrupting 120 megavolt-amperes (3-phase equivalent) and having a continuous current rating of 200 amperes. Three manufacturers co-operated in conducting such tests on their respective devices at the Oregon City Substation of the Bonneville Power Administration transmission system. Each switch was subjected to the same sequence of tests. The power system circuits were arranged to produce fault currents ranging from about 90 to 3,000 amperes (19 to 580 megavolt-amperes) which the switches were required to interrupt. One switch successfully interrupted nearly 4,000 amperes, or about 3/4 million kilovolt-amperes. Another series of tests provided line-charging currents from 9 to 44 amperes.

The interrupter switch was subjected to the various line-charging and fault currents by the proper arrangement of the 115-kv circuits. All tests used one phase only and were conducted on a single-pole switch. For the lower fault currents, a portable 3-phase 2,500-kva transformer was used, while higher currents were obtained by varying the connected kilovolt-amperes of generation and by the location of the fault on the system. Fault tests consisted of applying voltage (by closing the back-up circuit breaker) to the closed load-interrupter switch connected to the faulted bus. The interrupter switch was then opened automatically to interrupt the fault current, followed in a few cycles by opening of the back-up circuit breaker.

Results of the tests were highly satisfactory on all devices tested, and showed that load interrupter switches can be designed to give satisfactory operation considerably in excess of the requirements of the invitation, and at a cost that permits their consideration for small loads. There was no indication during the tests that the upper limit of interrupting ability had been reached. None of the switches were tested to destruction. The tests were stopped when indications of excessive mechanical stresses or insufficient dielectric strength indicated where designs should be modified to improve these limitations. In all the designs tested, apparent weaknesses revealed did not appear difficult to overcome. Tentative plans are being formulated for extending tests of this nature to 230 kv.

Field Tests on 115-Kv Interrupter Switch; *A. C. Schwager (Schwager-Wood Corporation, Portland, Oreg.).*

The need for an air-break switch capable of interrupting load currents and charging currents of transmission lines at transmission voltages has been recognized for many years. Tests scheduled by the Bonneville Power Administration for 115-kv interrupter switches led to the development of a test sample which was submitted to the entire series of tests scheduled. The interrupter switch was to be capable of interrupting load currents up to 600 amperes and charging currents of lines up to 100 miles long. Although these requirements correspond to an interrupting rating of a small fraction only of that of conventional oil circuit breakers, and therefore appears to be met by a very simple interrupting device, it is well known that even with conventional oil circuit breakers, charging current interruptions are often connected with distress and suggest the use of a modern interrupting device.

Because the interrupter switch is subject to severe atmospheric conditions, such as rain and sleet, and since it should be capable of giving satisfactory operation over long periods without inspection, it was decided to make use of an oil-blast-type interrupter mounted in a small insulated tank at the hinge end of a conventional air-break switch. The oil volume amounts to seven gallons per pole. Upon closing of the air-break switch, the contacts of the oil blast interrupter are closed and are connected in series with the switch blade. Upon the initiation of the opening of the air-break switch through its regular control pipe, the oil blast contacts open quickly, interrupting the current prior to the opening of the air-break contacts. A manually closed switch mechanism was developed which trips the interrupter switch in response to relay action with an opening time of approximately 20 cycles.

The interrupter switch was subjected to the entire series of tests scheduled. A single break type of oil blast interrupter was tested up to 250 megavolt-amperes. A 3-break oil blast interrupter was tested up to 750 megavolt-amperes. In all cases interruptions occurred without distress or oil throw with an opening time not exceeding 20 cycles.

After the tests, commercial designs were completed and several units, both for automatic transformer protection and line sectionalizing, are in operation on 115-kv systems since December 1948.

It is believed that the design developed, in view of the performance during these tests, will fill the need for a reliable, economical interrupter switch.

115-Kv Air Interrupter Switch; *P. B. Hoye (Electrical Engineers Equipment Company, Melrose Park, Ill.).*

A 250-megavolt-ampere 115-kv air interrupter switch has been developed and now made available for general nonautomatic switching beyond the range of horn gap switches and for automatic interruption of moderate fault currents. The general design incorporates an interruption means and coordinated disconnecting means. The arc is confined and interrupted in arcing chambers by gases produced by the action of the arc on solid material, and no oil or air blast is employed. Except for the top hardware, the switch is a simple, conventional, 2-insulator-type side break switch with standard insulation, spacing, and interphase linkage.

In place of the conventional blade is the interrupter unit containing series contacts in a porcelain housing. When the interrupter unit is in the "engaged" position these contacts can be opened or closed at high speed by a spring mechanism located at the hinge end of the interrupter unit.

Rotation of the hinge insulator counterclockwise further compresses the closing spring and then trips the latch. The contact rod is propelled at high speed to the closed position where it is automatically latched, the latter part of this motion being retarded by the opening spring which becomes compressed. In this way any shock is avoided, and the greater part of the accelerated energy is retained in the spring system, thereby minimizing the operating force and strain on the porcelain. If now, the insulator is rotated clockwise, the motion reverses—opening the contacts and leaving the closing spring compressed.

Continuation of the "trip open" motion of the insulator will swing the interrupter unit aside to the fully open position with a visible air gap. Now, if the rotation of the insulator is reversed, the interrupter unit swings to the "engaged" position, and the arcing contacts will close. The interrupter element consists essentially of an arcing chamber, a stationary and movable contact, and a capacitor. Both stationary and movable contacts are of tubular construction and separated by sections of arc-resistant insulating material.

Of particular interest is the construction of the arcing chamber. Its side walls are lined with vulcanized fiber tubes with conical bore which are telescoped and overlapped. These liners direct the flow of gases produced by the heat of the arc and have proved of great value in promoting arc interruption and in preventing restrikes. The exhaust gases are forced through and around the stationary

contact, into the capacitor and from there to the atmosphere.

For servicing in the field the contact rod with all contacts and all interrupting chambers may be withdrawn as a single unit.

115-Kv Load Break Switch Developments; *R. F. Gibbons (Pacific Electric Manufacturing Corporation, San Francisco, Calif.).*

The past few years have brought renewed interest in inexpensive circuit interrupters of low capacity and otherwise substandard performance, for special applications. The history of interrupters of this kind dates back to 1913 when the first unit was sold. By 1923 a large number of units rated 45 kv to 88 kv, 300 amperes were in service.

These early units were substantially air break switches with "plain break" oil interrupters. They were tested for line dropping on circuits of 12 to 117 miles length and for faults up to 125 amperes.

Recent activity has centered on the 115-kv 200-ampere 120,000-kva rating. Interruption of the exciting current of a 10,000-kva transformer bank and line charging currents corresponding to 100 miles of line is required. Automatic opening within 30 cycles of fault initiation appears to satisfy the time factor. These ratings approach the operating characteristics of the circuit breaker, departing from the idea of an air switch with an auxiliary interruptor.

Sample units of two oil-immersed designs, widely at variance in principle, were tested at the Bonneville Power Administration Oregon City Substation in March 1948. The units were not commercial models but were constructed principally to expedite testing. Both units performed on test in excess of the design requirements.

One of the units tested interrupted faults of 80 to 2,800 rms amperes, at 115 kv in five steps with arcing times not exceeding 1.3 cycles. Line dropping tests of 9 amperes, 20 amperes, and 40 amperes yielded arcing times not exceeding 1.0 cycle, without restrikes.

The conclusion that can be drawn from recent experience is that satisfactory "load break," or to use a better term, "interruptor" switches can be provided at reasonable cost and will give better protection than fuses. However, as refinements are added, such as automatic reclosing, the cost approaches that of the circuit breaker. This is especially true as the interrupting capacity is raised to encroach on that of the circuit breaker.

Conductor Armor for Reinforcement, Damping, Splicing, and Repair; *T. F. Peterson, J. C. Little (American Steel and Wire Company, Cleveland, Ohio).*

Longitudinal, mechanical, and electrical discontinuities in overhead conductors occur at splices, dead-ends, and at wire breaks. Transverse or radial discontinuities occur at the conductor surface, at insulator supports, and at taps. At points of transition such as encountered at the interface between conductor and insulation (air, porcelain, and so forth), problems are for the most part electrical and include such things as corona loss, arc-over characteristics, and the like; whereas, clamps, dead-ends, splices, and taps create mechanical and current carrying problems.

While a vast amount of work has been done over the years in the development of insulators and suspension clamps, it seems that characteristics of the latter have been weighted heavily to develop: support of the line under prescribed loading conditions, and longitudional holding strength. While cognizance has been taken of the need for designing supports to insure high corona forming voltage, to meet corrosion requirements, and to provide bearings and clamping areas to assure satisfactory support under certain vibrating conditions, by far the greatest emphasis seems to have been directed to development of straight support.

It should be recognized that design of splices and taps involves a great deal more than just meeting initial tensile strengths and conductivity requirements. Do they "freeze" otherwise free swinging, flexible conductors, thereby developing points of stress concentration? Are they subject to change due to cold flow of metals or differential expansion of dissimilar metals? Do corrosive conditions start progressive oxidation with subsequent cumulative acceleration due to corresponding increase in resistance? Do carrying capacities based on thermal characteristics of lines mean much if splices and taps are, in effect, "fuses in the line?"

From work which has been done over the past ten years, it is believed that preformed armor rods will go a long way towards solving many of the problems briefly touched on in the foregoing.

For conductor armor for protection at supports conventional armor rods consisting of soft aluminum wire are generally applied with the use of twisting wrenches. They are wrapped helically about the conductor and held in place by means of clamps or clips.

Preformed armor rods are made of hard spring-type wires preformed as helices and designed to fit on the specific conductor for which they are intended. As manufactured, the pitch length and inside diameter are very accurately determined and controlled, each preformed armor element being interchangeable with any other element for the same conductor size.

The armor pitch is in all cases in the same direction as the outer layer of the conductor while its length is somewhat less than the pitch length of the outer layer of the wires of the conductor. The armor inside diameter is approximately 85 per cent of the conductor outside diameter.

Vibration fatigue has been a subject receiving much laboratory and field study. The laboratory testing, as done in the present case, has been largely in connection with the smaller, rural, composite-type conductors. However, in addition to serving to evaluate the conductor practice used on these, they also serve to provide, in effect, pilot test results indicating the projected performance of similar practices used on larger conductors.

The conductor life (as measured by the development of a fatigue break in one wire) under forced vibration is greater with preformed armor than with any other practical reinforcement.

Since tapered aluminum armor rods for many years have been the accepted standard for adequate protection of the larger sizes of aluminum cable, steel-reinforced, the question has been asked whether preformed armor in the larger sizes provides comparable protection. Two armor constructions were tested under the same conditions in vibration fatigue. One employed tapered aluminum rods with clips applied to 397,500 circular-millimeters aluminum cable, steel-reinforced, and the other with preformed aluminum alloy armor rods applied in stepped fashion to the same type of conductor. From data obtained in this test, it could be surmised that the conductor life with each armoring method would be about the same—between 10 million and 12 million cycles.

Any relatively heavy mass attached to a conductor in vibration will tend to form a node and hence early conductor failure. The vulnerable points on large conductors are where the dampers are attached. On the smaller conductors, the application of hot line clamps creates a serious problem. Conductor failures normally occur in vibration near the point of attachment of the clamp. By attaching the clamp on the armored section of the conductor, failure under the clamp is minimized and conductor life extended many times.

Improved damping of preformed armor as measured in the laboratory and confirmed by observations in the field insures reduced vibration in field application, hence lower amplitude of vibration for shorter periods of time. Both are conducive to better operating performance and greatly prolonged conductor life.

The gripping of preformed armor rods on a conductor makes it possible to operate a line even after wire breaks occur. Since preformed armor rods may be used for splicing small conductor and repairing large conductors with many broken wires, a fatigue break within the armoring need not be considered the end point in conductor life.

The radiation area of a preformed armor assembly is much greater than the normal conductor area and the armor rods reduce conductor resistance. Both assist in maintaining conductor temperature within the armor rods at a value less than that of the line proper.

Arcing, either at taps or from arc-over at insulators, may cause some slight damage to the armor rods (it is usually slight because the armor rods are rugged by comparison with the conductor strands) but because of the perfect contact between the armor rods and conductor, the latter goes undamaged.

While the foregoing is concerned primarily with conductor supports, most of the characteristics are obtained and indeed desirable for conductor repairs, splices, taps, and dead-ends.

Preformed armor rods when made of suitable metals lend themselves to use as splices for various stranded conductors and ground wires. For application to high-voltage lines, they are designed so that corona loss per unit is negligible and the minimum corona forming voltage is very high. When applied to such lines, as well as to low-voltage lines, they make it possible to develop full current rating of the conductors since "hot spots" at taps, clamps, and splices are obviated.

INSTITUTE ACTIVITIES

AIEE Board of Directors Seeks Membership Views on Institute Policy

In April, the AIEE Board of Directors at Dallas received the Smith Resolution, which says in effect that AIEE should continue its prime interest in the technical field and make no pretense of entering into nontechnical fields; in May a special committee of the Board sent around a memorandum on this subject to the Sections; in June the Swampscott meeting of Section delegates discussed it, and the article in the June Electrical Engineering engendered voluminous correspondence (*EE, Jun '49, p 536*). Expressions of opinions pro and con are about evenly divided. Out of the discussion has come a substantial reassertion of opinion that some sort of an over-all engineering association with AIEE as one of its technical divisions is the ideal to be hoped for; there are, however, differences of opinion as to how to handle Institute policy in an intermediate period. In order to clarify and make more definite the field of discussion on the subject, the special committee wishes to direct the thinking of the membership toward answering several questions:

1. What is meant by nontechnical activities?
2. Can AIEE be really effective in such activities?
3. What would be the cost of undertaking such activities?

The Smith Resolution says, "..... it will be the policy of the Board of Directors to promote in every way the technical interests of our members to the exclusion of any other interests; ....." Technical interests of the Institute are of course presumed to include educational, student, and membership activities and the awarding of prizes and medals, as well as work more directly connected with progress of the art. Also, it is assumed that the Institute would continue to participate in the work of Engineers Council for Professional Development and Engineers Joint Council to the extent consistent with whatever interim policy is adopted.

What is meant by nontechnical activities? As to nontechnical interests, a tremendous range is covered in the varying opinions of the membership. Some think of the possibility of consciously planning to increase the prestige of engineers and cite the American Medical Association or the Bar Association as examples. Others think of efforts by the Institute to encourage legislation favorable to the engineer in connection with registration. Others think of participation by the Institute in civic affairs and effort to advise various governing bodies concerning public works. Others, particularly the younger members, think of efforts by the Institute to improve labor relations and rates of compensation. Nontechnical activities such as these would be excluded from specific Institute activity by the Smith Resolution. It is, however, presumed that regardless of the policy of the Institute the individual member will always have the same strong obligation to discharge his citizenship and professional responsibilities and should be so encouraged; discussion should concern itself as to whether or not the Institute can be set up to participate effectively in these matters, particularly during the interim period before the formation of an over-all engineering society.

Can AIEE be really effective in such activities? AIEE has done so well in purely technical fields that success in any nontechnical field it chooses to enter might reasonably be expected if sufficient time, money, and effort are expended. However, some of the difficulties should be recognized.

There is great diversity of interest among the membership. While many of the younger members are employed in various industries, many others are in supervisory positions; many are employers and many are self-employed. Many are in the educational field. While progress of the art is a common meeting ground for employer and employee, consultant and client, government ownership and private enterprise proponent, manufacturer and user, the same unanimity of approach is not present in the nontechnical field. A headquarters organization which could adequately serve its membership requirements in the nontechnical field would be a totally different outfit from the present one and obviously could not be developed overnight. To be effective in the nontechnical field both the new staff and new committee structure would be obliged to work hand-in-glove with the many engineering groups who should be co-operating in this field. Such obstacles however are not insuperable; many of them can be resolved in terms of cost.

What would be the cost of undertaking such activities? Nobody knows what the cost would be. Certainly common sense would say that there is additional cost involved. Although a very large amount could conceivably be spent, nevertheless membership ability to pay would probably limit additional income to that obtained by doubling the present dues, or roughly by adding about $15 annually to the dues bill of each individual member. For purposes of speculation the $15 annual increase per member can be expected to provide about a quarter-million dollars after expected downward membership adjustments and additional administration expense deductions.

A quarter-million dollars is a lot of money but how far it will go in this direction is a matter of conjecture. It probably would establish an addition to headquarters staff approximately equivalent in size and ability to the present staff. The addition to the staff and new Section and national committees would then be enabled to initiate required ground work on the many nontechnical subjects. An attractive activity can easily be imagined. The question remains: Shall we or shall we not enter wholeheartedly into nontechnical activities?

Many correspondents and discussers have suggested some middle-of-the-road compromise. The number of compromises possible is legion, but general agreement on one of a multitude of such courses is impossible. Experience with attempts to follow a middle course, by spasmodic and intermittent dabbling in extraneous fields, have yielded generally unsatisfactory results. Consequently, the Board of Directors feels that there are two possible consistent courses as indicated in the following, and seeks the views of the membership on which one should be followed:

1. Adhere to technical field.
2. Expand in nontechnical field with substantially increased dues.

Which course do you favor?

BALLOT

Membership Views on Institute Policy

CHECK ONE

☐ I favor adhering to technical field.

☐ I favor expanding in nontechnical field with substantially increased dues.

Signature.....

Please mail to your Section Chairman or Secretary.

Comprehensive Program Planned for AIEE 1949 Fall General Meeting

Arrangements for the 1949 Fall General Meeting to be held in Cincinnati, Ohio, October 17–21, have been completed. Headquarters for the meeting will be in the Netherland Plaza Hotel. The technical program is broad in scope and embraces a number of sessions in each of the five technical groups of Institute activity, namely: Communications, Industry, Science and Electronics, General Applications, and Power.

A delightful series of events, consisting of a stag smoker, dinner-dance, inspection trips, and a special ladies' program, have been arranged by the Fall General Meeting Committee.

STAG SMOKER

Tuesday evening, October 18, at 7:00 p.m., the stag smoker will be held in the Pavilion Caprice of the Netherland Plaza Hotel. The cost will be $6 per person.

This is the evening "when good fellows get together" to renew old friendships and make new ones. It will include a hearty dinner, planned for men's appetites, and a variety of music and entertainment to provide an hour of laughs and relaxation.

DINNER-DANCE

Wednesday evening, October 19, at 7:00 p.m., a dinner-dance will be held in the Pavilion Caprice of the Netherland Plaza Hotel. The cost will be $4 per person. Dress is optional. Dancing will be from 8:30 p.m. to 12:30 a.m.

LADIES' PROGRAM

A program for the ladies visiting the convention will begin Monday afternoon with a "Get-Acquainted Tea" in the Julep Room at the Netherland Plaza Hotel.

At 9:00 a.m. Tuesday, the ladies will board chartered busses for a trip to Procter and Gamble Company, the world's largest manufacturer of soaps, also manufacturers of Drene, Crisco, and numerous other cosmetics.

At 2:00 p.m. Tuesday, busses will again pick up visitors for a trip to the Taft Art Museum for tea. This museum, the home of Mr. and Mrs. Charles Taft, is considered the finest example of early Federal architecture in the United States. The fine collection of paintings, furnishings, and Chinese porcelains were the gift of the Tafts also. Tea will be preceded by a short talk on the museum and its treasures, which will make this one of the highlights of the convention.

Tuesday evening, while the men attend the traditional smoker, some outstanding entertainment will be provided for the ladies.

Wednesday morning, busses will again pick up the visiting ladies for a scenic tour of the city ending with luncheon at the Hyde Park Country Club.

Thursday morning, the ladies will be guests at a luncheon at the attractive Dean Schneider Memorial, headquarters of the Engineering Society of Cincinnati. This luncheon will be sponsored by the Womens' Committee of the Engineering Society.

No formal entertainment has been planned for Friday, but individual arrangements will be made for those remaining in the city for sightseeing, shopping, and so forth.

The entire program, including all ladies' entertainment functions and transportation, will be offered to the ladies for a total charge of $3.

INSPECTION TRIPS

The following inspection trips have been scheduled during the 1949 Fall General Meeting. Admission will be by ticket only and it is very important that members and their guests register at the Inspection Trip Desk whether they have private transportation or not. The registration is necessary in the cases of men having their own transportation since the number of men permitted to make the inspection trips is definitely limited in most instances.

The Baldwin Company. A tour through the Baldwin Company manufacturing plant affords the visitor an unusual opportunity to observe a remarkable association of modern engineering and scientific proficiencies allied with age-old traditions of artistic skill and craftsmanship—a unique combination not often found in American industry. Here one may see many unhurried processes whose effectiveness has been proved by centuries of development and perfection in the art of creating fine pianos and one may see also the laboratories where engineers and technologists study the science of musical instruments and the development of new forms such as the Baldwin electronic organ.

To show that the science and art of making pianos is not a static thing, the acoustic studio and piano research laboratory will be visited, with a short nontechnical discussion and demonstration of the interesting work of this activity.

The tour is brought to an interesting conclusion with a "Pops" Concert and demonstration in the popular scientific manner.

This trip is scheduled for Monday and Tuesday, October 17 and 18, at 1:30 p.m.

The Procter and Gamble Company. The Ivorydale Factory of the Procter and Gamble Company is the heart of the largest soap manufacturing center in the world. Ivorydale is composed of 123 buildings spread over 173 acres, and employs more than 2,000 people. Many hundreds more are employed in the company's St. Bernard and Drug Products Factories nearby. Visitors to the plant will see soap made in the giant 3-story kettles and processed into bars, flakes, and granules. Of particular interest are the high-speed packaging machines which form cartons, fill, seal, and pack them. Visitors also will see the control laboratory where more than 30,000 tests are run each month, and the company's vegetable shortening facilities.

This trip is scheduled for Monday and Tuesday, October 17 and 18, at 1:30 p.m.

Fisher Body Plant, General Motors Corporation, Hamilton, Ohio. This plant is engaged in the fabrication of metal parts for General Motors automobile bodies. The acceleration, speed, and torques developed by the motor operating the large presses and stamping machines, as well as the safety features incorporated in all of the equipment, should be of special interest.

This trip is scheduled for Wednesday and Thursday, October 19 and 20, at 1:15 p.m.

Miami Fort Generating Station, The Cincinnati Gas and Electric Company. This station, located on the Ohio River 20 miles west of Cincinnati, was placed in operation in 1925. With the completion of the present addition, scheduled for operation by November 1, 1949, the station will have a rating of 336,000 kw.

The present construction program covers the installation of a 13,800-volt 80,000-kw 0.8-power-factor 1,250-pounds-per-square-inch 950-degrees-Fahrenheit hydrogen-cooled turbogenerator directly connected through 5,000-ampere isolated-phase bus duct to a 100,000-kva class *FOW* 13.2–132-kv transformer bank. Previous installa-

Fall General Meeting Committee

Members of the General Committee for the 1949 Fall General Meeting, to be held in Cincinnati, include (front row, left to right) W. H. McNutt, R. J. Rockwell, E. S. Fields (Chairman), F. W. Willey, F. E. Wiatt, and (back row, left to right) D. T. Michael, J. A. Noertker, W. T. Pavely, A. C. Burroway, H. E. Barnett, J. P. Quitter, R. E. Colado, S. B. Storer, E. F. Nuesel

Tentative Technical Program

Fall General Meeting, Cincinnati, Ohio, October 17–21

Monday, October 17

9:30 a.m. Rotating Machinery

49-225. The Design of D-C Motors for Use in Automatic Control Systems. *Paul Lebenbaum*, General Electric Company. Presentation by title only

49-226. Limitations in Design of D-C Adjustable Speed Motors. *L. G. Opel*, Westinghouse Electric Corporation. Presentation by title only

49-227. Use of Cumulative and Differential Series Fields in the Parallel Operation of Motors. *A. W. Kimball*, Westinghouse Electric Corporation. Presentation by title only

49-231. Measuring Commutation With an Indicating Instrument. *R. T. Lundy*, General Electric Company. Presentation by title only

49-229. Transient Characteristics of D-C Motors and Generators. *A. T. McClinton, E. L. Brancato, Robert Panoff*, Naval Research Laboratory

49-230. The Eccentric Pole Face—A Means to Better D-C Machine Performance. *M. A. Baker*, General Electric Company

49-231. An Analysis of Rotating Amplifiers. *Bernard Litman*, Arma Corporation

49-232. Temperature Rise Values for D-C Machines—II. *Subcommittee on D-C Machines*

9:30 a.m. Probability Methods

49-278. A Convenient Method for Determining Generator Reserve. *H. P. Seelye*, The Detroit Edison Company

49-279–ACO.* Allocation of Capacity Savings Resulting From Interconnecting Two or More Generating Systems. *C. W. Watchorn*, Pennsylvania Water and Power Company

CP. Determination of Reserve Capacity by the Probability Theory—Simplified Methods.** *G. Calabrese*, New York University

CP. Relation of Thermo Flap Design to Reserve Capacity Requirements.** *M. J. Steinberg*, Consolidated Edison Company of New York, Inc.

9:30 a.m. Industrial Power Systems

49-223–ACO.* Electrical Distribution System for a Mexican Cement Plant. *Leo Dollert*, Latin American Export Service

CP. Power Distribution in Textile Mills.** *John Wesley Davis, George Wrigley*, J. E. Sirrine Company

CP. Electrical Maintenance Problems in Continuous Process Plants.** *T. O. Sweatt*, Wearn, Vreeland, Carlson and Sweatt, Inc.

CP. Interior Wiring Design for Commercial Buildings.** *Subcommittee on Interior Wiring Design for Commercial Buildings*

2:00 p.m. Rotating Machinery

49-234. Progress Report on AIEE Test Code for Electric Brushes. *Joint Subcommittee on Electric Brushes*

49-235. Differential Leakage of the Different Patterns of a Fractional Slot Winding. *M. M. Liwschitz*, Polytechnic Institute of Brooklyn

49-236. Flywheel—Induction Motor Drives. *Joseph Ben Uri*, Tel-Aviv, Palestine

49-237. Motor Tests Evaluate Thermal Endurance of Class H Insulation and Silicone Varnish. *George Grant III, T. A. Knappi*, Dow Corning Corporation; *G. L. Moses, G. P. Gibson*, Westinghouse Electric Corporation

2:00 p.m. Speed Governing

49-288. Governors and the AIEE-ASME Governor Performance Specification. *A. F. Schwendner*, Westinghouse Electric Corporation; *Wayne Astley*, Philadelphia Electric Company

49-289. Automatic Load Control for Turbine Generators. *H. B. Read*, Iowa-Illinois Gas and Electric Company; *S. B. Farnham*, General Electric Company

49-290. Determining Incremental Regulation and Dead Band of Governors on Steam Turbine Generators Under System Load Conditions. *E. L. Torquist, I. L. Wade*, Public Service Company of Northern Illinois

49-291. The Performance of a Topped Steam Power Plant on Sudden Load Reduction. *John G. Noest*, Consolidated Edison Company of New York, Inc.

2:00 p.m. Instruments and Measurements

49-275–ACO.* A Circuit to Correct Ammeter and Wattmeter Reading for Current Drawn by Voltmeter and Wattmeter Potential Coils. *L. L. Shumaker, G. A. Nyhouse*, Delco Products, Division of General Motors Corporation

49-276–ACO.* The Irradiation of Spark Gaps for Voltage Measurement. *D. R. Hardy, J. D. Craggs*, The University of Liverpool

49-277–ACO.* A Double-Input Oscilloscope for the Study of Laboratory A-C Circuits. *Paul M. Kintner*, University of Illinois

49-292–ACO.* Ammeter as Direct Reading Power Factor Meter. *Joseph Ben Uri*, Tel-Aviv, Palestine

2:00 p.m. Conference on Undervoltage Protection of Motorized Devices

CP. The Effect of Undervoltage Protection on the Power System.** *W. R. Weiss*, Cincinnati Gas and Electric Company

CP. Undervoltage Protection of Equipment.** *R. A. Hess*, Armco Steel Corporation

CP. Undervoltage Protection of Motorized Devices.** *J. C. Lynch*, Hammermill Paper Company

CP. Undervoltage Protection of Motor Drives.** *J. E. Arberry*, Pittsburgh Plate Glass Company

CP. Aspects of Time-Delay Undervoltage Protection as It Affects Industrial Control.** *E. H. Alexander*, General Electric Company

Tuesday, October 18

10 a.m. General Session

President J. F. Fairman, presiding
Welcome. Dr. Raymond Walters, President, University of Cincinnati
"Professional Unity at the Grass Roots." J. F. Fairman, President AIEE
Address
Presentation. Prize Paper Awards

2:00 p.m. Rotating Machinery

49-238. General Theory of Multiple Cage Induction Motors. *S. S. L. Chang*, Robbins and Myers, Inc.

49-239–ACO.* Reactive Speed-Torque Control of Squirrel-Cage Induction Motors. *R. V. Tiede*, The Johns Hopkins University

49-240. Saturation Effect on Leakage Reactance. *S. S. L. Chang, T. C. Lloyd*, Robbins and Myers, Inc.

49-241. The Torques of the Synchronous Tie—A Steady-State Analysis. *L. A. Finzi, H. M. McConnell*, Carnegie Institute of Technology

2:00 p.m. System Economics

49-242. Co-ordination of Fuel Cost and Transmission Loss by Use of Network Analyzer to Determine Plant Loading Schedules. *E. E. George, H. W. Page*, Ebasco Services, Inc., *J. B. Ward*, Purdue University

CP. Phase Shifting 22-Kv Regulators Save System Investment.** *V. E. Hill*, Duquesne Light Company

49-287–ACO.* New Suspension Clamp for Transmission Line Conductors. *Sverre Sandberg*, Svenska Aluminiumkompaniet

2:00 p.m. Industrial Control

49-243–ACO.* Press Control With an Eddy-Current Drive. *B. H. Carlisle, Jr.*, The Clark Controller Company

CP. Spotting Control of Synchronous Motors.** *S. C. Ewing, E. A. E. Rich*, General Electric Company

CP. A Proposed Classification of Regulating Systems.** *S. L. Burgwin*, Westinghouse Electric Corporation

CP. Fundamentals of Analysis of Regulating Control Systems for Industrial Applications.** *W. Alvarez, E. S. Dyche*, General Electric Company

49-244. Prediction of Ultimate Temperature Rise From Early Heat Run Data. *J. E. Ryan*, General Electric Company. Presentation by title only

2:00 p.m. Problem and Thesis Subjects From Industry

CP. Electrical Application Problems for Engineering Education.** *F. R. Benedict, W. R. Harris, R. L. Wittke*, Westinghouse Electric Corporation

CP. Electrical Design Problems for Engineering Education.** *T. M. Linville, K. B. McEachron, Jr.*, General Electric Company

CP. Industrial Electronic Problems for Engineering Education.** *Walther Richter*, Allis-Chalmers Manufacturing Company

Wednesday, October 19

9:30 a.m. Protective Devices

49-280–ACO.* Application Guide on Methods of Neutral Grounding of Transmission Systems. *Working Group of Subcommittee on Fault Limiting Devices*

49-281–ACO.* Application Guide for the Grounding of Synchronous Systems. *Working Group of Subcommittee on Fault Limiting Devices*

49-282. Operation of A Ground Fault Neutralizer on a Regulated Distribution System. *H. R. Tomlinson, F. B. Hunt*, New England Power Service Company

49-283–ACO.* Guide for Application of Ground-Fault Neutralizers. *Working Group of Subcommittee on Fault Limiting Devices*

9:30 a.m. Conference on Applications of Conformal Mapping in Electric Circuit Analysis

CP. Basic Theory of the Generalized Schwarz-Christoffel Transformations and Their Use in Electric Circuit Analysis.** *Thomas J. Higgins*, The University of Wisconsin

CP. The Potential Analogue in Network Synthesis and Analysis.** *W. H. Huggins*, Air Materiel Command

9:30 a.m. Conference on Railroad Communication

CP. Train Communication in Railroad Operations.** *F. H. Menagh*

CP. Wire Communication System of the Santa Fe Railroad.** *L. R. Thomas*

49-245. Centralized Traffic Control for Railroads. *W. D. Hailes*, General Railway Signal Company

CP. Line Circuits for Centralized Traffic Control.** *G. W. Baughman*

9:30 a.m. Rotating Machinery

49-294. Transients in 2-Phase Synchronous Machines. *N. E. Wilson*, University of Massachusetts

49-296. Design of Auxiliary Circuits of Single-Phase Induction Motors. *M. S. Thacker, H. V. Gopalakrishna*, Indian Institute of Science

49-295. The Dynamoelectric Amplifier—Class A Operation. *R. M. Saunders*, University of California

2:00 p.m. Protective Devices

49-284. Report on Survey of Unbalanced Charging Currents on Transmission Lines as Affecting Ground Fault Neutralizers. *Subcommittee on Fault Limiting Devices*

49-286. Performance Characteristics of Lightning Protective Devices. *Subcommittee on Lightning Protective Devices*

2:00 p.m. Conference on Voltage Induction

2:00 p.m. Symposium on Technical Design of Coaxial Television and Telephone Systems

49-246. Attenuation and Delay Equalizers for Coaxial Lines. *W. R. Lundy*, Bell Telephone Laboratories, Inc.

49-247. Stability of Tandem Regulators in the L-1 Carrier System. *J. P. Kinzer*, Bell Telephone Laboratories, Inc.

49-248. Equalization of Coaxial Lines. *K. E. Gould*, Bell Telephone Laboratories, Inc.

49-249. Television Terminals for Coaxial Systems. *L. W. Morrison, Jr.*, Bell Telephone Laboratories, Inc.

2:00 p.m. Aluminum

49-250–ACO.* Aluminum and the Electrical Industry. *Donald M. White*, The Aluminum Association

CP. Aluminum Rolled Products in Relation to the Electrical Industry.** *D. W. Smith*, The Permanente Metals Corporation

CP. Aluminum Extruded and Drawn Products in Relation to the Electrical Industry.** *H. V. Menking*, Reynolds Metals Company

Thursday, October 20

9:30 a.m. Transmission and Distribution

49-251. Report of a Survey on the Performance of Shunt Capacitors. *Joint Working Groups of the Capacitor Subcommittee of AIEE and EEI Transmission and Distribution Committees*

49-252. Report on the Operation and Maintenance of Shunt Capacitors. *Working Group of Capacitor Subcommittee on Transmission and Distribution Committee*

49-253. The Calculated Risk of Operating Capacitors Without Individual Fuses. *Hamilton Brooks*, Westinghouse Electric Corporation

49-254. Connection Arrangements and Protective Practices for Shunt Capacitor Banks. *N. R. Clark, S. B. Farnham*, General Electric Company

9:30 a.m. Mining and Metal Industry

49-255–ACO.* Selection of Optimum Rating of Mercury Arc Rectifiers for Coal Mining Service. *L. W. Scott*, General Electric Company, *J. A. Dunn*, Island Creek Coal Company

CP. Redesign of 5-Horsepower Open Motors for Explosionproof Pumping and Conveyor Service.** *W. R. Wood*, The Berwind-White Coal Mining Company

CP. Analysis of Power Costs of Bituminous Coal Mines.** *H. P. Musser*, West Virginia Engineering Company

CP. Electric Machinery Inspection Technique and Problems.** *W. W. Mattox*, Armco Steel Corporation

9:30 a.m. Radio

49-256. Design of Mobile Radio Communications Equipment for Land-Mobile Services Operating on Frequencies Between 152-174 Megacycles. *R. A. Burr, W. A. Harris, A. D. Zappacosta*, Radio Corporation of America

CP. The Transition Air Navigation System and Its Evolution.** *S. A. Mundell*

CP. Technical Features of Air-borne and Ground Distance Measuring Equipment.** *C. J. Hirsch, R. B. Brunn, H. L. Blaisdell*

—PAMPHLET reproductions of author's manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.

—PRICES for papers, irrespective of length, are 30 cents to members (60 cents to nonmembers) whether ordered by mail or purchased at the meeting. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.

—COUPON books in nine-dollar denominations are available for those who may wish this convenient form of remittance.

—THE PAPERS regularly approved by the technical program committee ultimately will be published in Proceedings and Transactions; also, each is scheduled to be published in Electrical Engineering in digest or other form.

9:30 a.m. Conference on Machine Tools

CP. The Application of the Rototrol to Machine Tools.** *M. H. Fisher*, Westinghouse Electric Corporation

CP.* Electrification of a Large Planer-Type Milling Machine. *J. W. Harper*, General Electric Company

CP. Electronic Control as Applied to Grinders.** *J. M. Morgan*, Cincinnati Milling Machine Company

2:00 p.m. Mining and Metal Industry

CP. Shuttle Cars and Electrical Problems Encountered in Their Use.** *J. W. Woolf*, Joy Manufacturing Company

CP. Electric Control of Belt Conveyors.** *W. R. Roberts*, The Jeffrey Manufacturing Company

CP. Cable Reel for Use on Mine Locomotives.** *J. R. Doig*, General Electric Company

CP. Trolly Phone Mine Communication.** *W. P. Place*, Farmers Engineering and Manufacturing Company

2:00 p.m. Television

49-257–ACO.* A 500-Watt Visual 250-Watt Aural Television Transmitter. *L. Voorhees*, Allen B. Du Mont Laboratories, Inc.

49-258–ACO.* Low-Voltage and High-Voltage Power Supplies for Home Television Receivers. *Victor Wouk*, Beta Electric Corporation

49-259–ACO.* Effect of Man-Made Noise on Television Receivers. *G. D. Hulst*, Allen B. Du Mont Laboratories, Inc.

CP. Microwave Television Relay for Navy Training Program.** *H. Cook*

Friday, October 21

9:30 a.m. Relays

49-260. A New Loss-of-Excitation Relay for Synchronous Generators. *C. R. Mason*, General Electric Company

49-261. A One Slip Cycle Out-of-Step Relay Equipment. *W. C. Morris*, General Electric Company

49-262. Novel Test Circuits for Protective Relays. *W. K. Sonnemann*, Westinghouse Electric Corporation

49-263. Insulation Level of Relay and Control Circuits. *Project Committee on Insulation Level of Relay and Control Circuits*

9:30 a.m. Insulated Conductors and Accessories

49-264. A New Technique in the Manufacture of Soldered Porcelain Potheads. *A. E. Papp, J. H. Nicholas*, G & W Electric Specialty Company. Presentation by title only

49-265. Design Fundamentals of Potheads 69,000 Volts and Below. *J. H. Nicholas*, G & W Electric Specialty Company

49-266. Cable Accessory Design Utilising New Laboratory Techniques. *P. N. Bosworth, H. K. Farr*, General Electric Company

49-267. A Theoretical and Practical Approach to the Design of High-Voltage Cable Joints. *H. D. Short*, Canada Wire and Cable Company

49-268. Transient Temperature Phenomena of 3-Conductor Cables. *F. G. Wallaston*, B. C. Electric Railway Company

9:30 a.m. Electronic Power Converters

49-269–ACO.* Protection of Electronic Power Converters—Part II. *Subcommittee on Electronic Converter Circuits*

49-270. Diagnosis of Rectifier Ailments. *I. K. Dortort*, Allis-Chalmers Manufacturing Company

CP. Preliminary Report on Survey of Operation of Mercury Arc Rectifiers.** *Subcommittee on Electronic Converter Application*

49-271. Rectifier Transformer Characteristics. *Subcommittee on Rectifier Transformers.* Presentation by title only

9:30 a.m. Conference on Machine Tools

CP. Automatic Programming of Machine Cycles.** *R. N. Eck*, Cutler-Hammer, Inc.

CP. What the Automotive Industry Expects of Electric Equipment on Machine Tools.** *W. B. Nichol*, Chevrolet Division of General Motors Corporation

CP. Motor Ripple Voltage and Its Application to Plugging Relays.** *S. Noodleman*, Standard Dayton Corporation

CP. A New Control for Direct Drive Presses.** *W. E. Large*, Westinghouse Electric Corporation

2:00 p.m. Substations

49-272. Space Code Selector Supervisory System. *E. F. Forrest, P. W. Schirmer*, General Electric Company

49-285–ACO.* Basic Single-Line Diagrams for Substations. *H. P. Candarie, H. P. Smith*, The Hydro-Electric Power Commission of Ontario

49-273–ACO.* Functional Development of 66-Kv Switching and Transformer Stations. *N. N. Smeloff*, Pennsylvania Power and Light Company

49-274–ACO.* Safety in Substation Design. *J. O. Leslie, D. L. Greene*, Gilbert Associates, Inc.

49-293. A-C Tripping and Reclosing of Line Sectionalizing Circuit Breakers. *C. E. Wimgartner, H. E. Boehmer*, The Cleveland Electric Illuminating Company

49-228–ACO.* Proposed American Standard Guide for Loading Oil-Immersed Step-Voltage and Induction-Voltage Regulators. *Working Group on Operating Guide for Regulators.* Presentation by title only

2:00 p.m. Conference on Machine Tools

CP. Opportunities for Electrification of Machine Tools in Railroad Shops.** *V. P. Schmidt*, The Pennsylvania Railroad

CP. Magnetic Clutch and Brake Application on Production Lathes and Milling Machines.** *B. T. Anderson*, Sundstrand Machine Tool Company

CP. General Principals of Applying Clutches and Brakes to Machine Tools.** *Glenn Spohn*, Gregg and Spohn, representing Warner Electric Brake Manufacturing Company

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*ACO: Advance copies only available; not intended for publication in *Transactions*.

**CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

tions had 13.2-kv horizontal phase separated switching with fault bus protection in both concrete cell and metal enclosed types.

Power is transmitted from this station over 33-kv, 66-kv, and 132-kv lines. The 132-kv switching structures are fault bus protected.

All coal is received in barges operating on the Ohio River and is conveyed from the unloading tower to the station by endless belt conveyors. Coal is handled to and from storage by means of wagon scrapers. Pulverizing is accomplished by means of a centralized bin system and also by unit pulverizers.

This trip is scheduled for Wednesday, October 19, at 1:15 p.m., and Thursday, October 20, at 9:00 a.m.

Engineering Society of Cincinnati. The inspection trip and forum will put on display the fine facilities provided by Cincinnati's Herman Schneider Foundation for use by the engineering, scientific, and technical organizations in the vicinity and will indicate how the foundation, The Engineering Society of Cincinnati, and the societies participating in Cincinnati's Council of Technical and Scientific Societies, complement and supplement each other in a unique program of co-operation.

This trip is scheduled for Wednesday, October 19, at 11:30 a.m. Luncheon at the foundation will be served at 12:30 p.m.

Oakley Colony. This includes The Cincinnati Milling and Grinding Machine Company, the Cincinnati Planer Company, and The Cincinnati Bickford Tool Company. To be seen are the latest applications of electric control to milling machines, grinding machines, planes, and drilling machines. At the same time, the modern plants in which these machines are made, and the machines themselves in various stages of construction, will be shown. The Oakley Colony is probably one of the largest and most modern centers of machine tool production.

This trip is scheduled for Thursday, October 20, at 1:30 p.m.

Crosley Broadcasting Corporation, Television Station WLW-T, and Frequency Modulation Station WLW-A. An inspection trip will be made to the television station and studios of stations *WLW-T* and *WLW-A*. Station *WLW-T* has a visual power of 34 kw and an aural power of 17 kw. Station *WLW-A* has a frequency-modulated output of 20 kw. The entire station will be inspected including studios, control rooms, transmitter rooms, movie projection rooms, and a movie film development room. A special triplex filter for the antenna, which is used for both *WLW-T* and *WLW-A* (frequency modulation) signals, will be explained. The studio building is one of the highest concrete block buildings in the United States. An excellent panoramic view of the city of Cincinnati can be seen from the entrance porch to the station.

(*Note:* The scheduling of this trip will depend on the studio schedule.)

The committee will be pleased to assist in making arrangements to other places if any registrants so desire. Watch the bulletin boards for these and other trips.

HOTEL RESERVATIONS

In the Netherland Plaza Hotel all rooms are outside rooms with tub, shower, and 4-station radio. Room rates per day are as follows:

Single room	$ 4.00–$10.00
Double bedroom for two	8.00– 12.00
Twin bedroom for two	9.00– 13.00
Suite: parlor and bedroom	18.00– 35.00

All requests for room reservations should be sent directly to the Netherland Plaza Hotel, Fifth and Race Streets, Cincinnati 2, Ohio. Members are urged to send in their requests early. The Netherland Plaza Hotel will place overflow reservations in adjacent hotels, including the Terrace Plaza, Hotel Gibson, and Hotel Sinton at comparable rates.

MEETING COMMITTEES

Members of the Fall General Meeting Committee making arrangements are as follows:

E. S. Fields, *Chairman;* R. J. Rockwell, *Vice-Chairman;* J. P. Quitter, *Secretary;* W. H. McNutt, *Treasurer;* J. C. Strasbourger; R. E. Stoppel; F. E. Wiatt

The chairmen of the various subcommittees are

A. C. Burroway, E. P. Nuesel, *Technical Program;* W. T. Pavely, *Inspection Trips;* S. B. Storer, *Entertainment;* J. A. Noertker, *Transportation;* D. T. Michael, *Registration;* F. W. Willey, *Finance;* R. E. Colado, *Publicity;* Mrs. J. A. Noertker, *Ladies;* H. E. Barnett, *Hotel and Equipment*

AIEE Board of Directors Holds Regular Meeting in New York

A regular meeting of the AIEE Board of Directors was held at Institute headquarters, New York, N. Y., August 5, 1949.

Minutes of the meeting of the Board of Directors held in Swampscott, Mass., June 23, 1949, were approved.

Walter J. Barrett, of Newark, N. J., was elected a Director of the Institute for the unexpired term, ending July 31, 1950, of James F. Fairman, President for this year.

Recommendations adopted by the Board of Examiners at its meeting on July 21, 1949, were reported and approved. The following actions were taken upon recommendation of that board: 24 applicants were transferred and one was elected to the grade of Fellow; 119 applicants were transferred and 54 were elected to the grade of Member; 532 applicants were elected to the grade of Associate; 148 Student members were enrolled.

Further consideration was given to the report on uniform grades of membership, prepared by a conference of representatives of the member societies under the auspices of the Engineers' Council for Professional Development, which was accepted in principle by the Board of Directors on June 23, 1949, with the understanding that it would be considered further at the August meeting of the board. The ECPD Committee on Professional Recognition will submit these proposed standard nomenclatures and definitions of membership grades to the Engineers' Council for Professional Development for approval. The board voted to authorize the AIEE representatives on ECPD to approve them on behalf of the Institute; also, the board voted to indicate to the other societies its willingness to take the necessary steps to bring about their adoption by the AIEE membership, through the required amendments to the constitution and bylaws, provided two or more of the other societies will do likewise.

Disbursements in July 1949 amounting to $79,868.38 were reported by the Finance Committee and approved by the board. This amount reflected typical monthly expenditures, with the exception of two items: one, the Summer General Meeting travel expense allowance; and the other, the purchase of badges.

Chairman Yerkes of the Finance Committee reported comparative figures of income and expenditures for this appropriation year and last year, as follows: Income October 1 to July 22 inclusive—this year, 88 per cent to the budget income, last year, 85.4 per cent; expenditures for the ten months ending July 31—this year, 85.4 per cent of the budget, last year, 84.3 per cent.

As required by the bylaws of the Edison Medal Committee, the board confirmed the appointment by the President of John L. Callahan, John M. Flanigen, and Roger I. Wilkinson as members of the committee for 5-year terms beginning August 1, 1949, and of J. R. North for the unexpired term, ending July 31, 1951, of S. M. Dean, deceased, and the appointment of J. B. MacNeill as chairman of the committee for the year 1949–50. The board also elected from its own membership, to serve on the committee for 2-year terms beginning August 1, 1949, W. L. Everitt, A. H. Frampton, and A. C. Monteith.

The following actions were taken in accordance with the bylaws of the committees concerned: Approved the appointment by the President of F. W. Bush and A. G. Conrad as members of the Charles LeGeyt Fortescue Fellowship Committee for 3-year terms beginning August 1, 1949, and his appointment of C. B. Jolliffe, A. H. Kehoe, and J. B. MacNeill to the Lamme Medal Committee for terms of three years beginning August 1, 1949.

The plan for the administration of the Volta Scholarship Fund, which was adopted by the Board of Directors on June 23, 1949, specified that grants from the fund shall be administered by three trustees appointed by the board of directors for 6-year terms, the terms to be staggered so that one term expires every two years. Accordingly, the Board of Directors appointed three trustees, as follows: W. L. Everitt, for the term of two years ending July 31, 1951; C. A. Powel for the 4-year term ending July 31, 1953; and H. S. Osborne to July 31, 1955.

The annual appointment of standing representatives of the Institute was made (see list on page 804 of the September issue).

Local Honorary Secretaries of AIEE were reappointed for 2-year terms beginning August 1, 1949, as follows: Richard H. Bowles, for Brazil; Sir A. P. M. Fleming, for England; Edy Velander, for Sweden; R. D. Neale, for New Zealand. P. H. Powell was designated to act as Local Honorary Secretary in place of R. D. Neale during the latter's absence from the country.

The 1951 Winter General Meeting was scheduled to be held in New York, N. Y., January 29–February 2.

Chairman M. D. Hooven of the special Committee on Institute Policy covering technical, civic, and professional activities, presented a draft, which was discussed, of a statement headed "Membership Views on Institute Policy," which the committee proposed to send to the Sections for discussion and to publish in the October issue of *Electrical Engineering* (*p 890*), in an effort to obtain the views of the members regarding Institute activities.

A proposed letter over the signature of the President, extending the congratulations of the Board of Directors to Ex-President of the United States Herbert Hoover (Honorary Member, AIEE) on the occasion of his 75th birthday was approved.

Chairman R. K. Honaman of the Committee on Public Relations reported recommendations of the committee for expanded activity in a continuing program of public relations throughout a trial period of one year and the board appropriated $9,000 for this work, most of which will be spent on professional assistance.

It was decided to hold the next meeting of the board in Cincinnati, Ohio, on Thursday, October 20, during the Fall General Meeting.

Report was received from the Standards Committee of the appointment of AIEE representatives on the Electrical Standards Committee of the American Standards Association:

Representatives—John Grotzinger, F. E. Harrell, J. J. Pilliod

Alternates—H. E. Farrer, I. W. Gross, E. B. Paxton

Assignment to divisions:

Power Division—I. W. Gross, John Grotzinger, E. B. Paxton

Communication and Electronics Division—H. E. Farrer, F. E. Harrell, J. J. Pilliod

Approval was given to the appointment by ECPD of the following AIEE members of committees of the Engineers' Council for Professional Development:

Committee on Student Selection and Guidance—H. W. Bibber
Committee on Engineering Schools—Sidney Withington
Committee on Professional Training—J. W. Barker, Donald Bridgman
Committee on Professional Recognition—R. H. Barclay
Region II Committee of Committee on Engineering Schools—H. N. Muller
Regional VII Committee of Committee on Engineering Schools—Eugene W. Schilling

Other matters were discussed, reference to which may be found in this or future issues of *Electrical Engineering*.

There were present:

President—James F. Fairman, New York, N. Y.
Past President—Everett S. Lee, Schenectady, N. Y.
Vice-Presidents—J. L. Callahan, New York, N. Y.; W. C. DuVall, Boulder, Colo.; Ralph A. Hopkins, Los Angeles, Calif.; Richard McKay, Spokane, Wash.; G. N. Pingree, Dallas, Tex.; W. J. Seeley, Durham, N. C.; Victor Siegfried, Worcester, Mass.; C. G. Veinott, Lima, Ohio

Directors—E. W. Davis, Cambridge, Mass.; W. L. Everitt, Urbana, Ill.; C. W. Fick, Cleveland, Ohio; R. T. Henry, Buffalo, N. Y.; N. B. Hinson, Los Angeles, Calif.; M. D. Hooven, Newark, N. J.; F. O. McMillan, Corvallis, Oreg.; A. C. Monteith, Pittsburgh, Pa.; Elgin B. Robertson, Dallas, Tex.; H. J. Scholz, Birmingham, Ala.; E. P. Yerkes, Philadelphia, Pa.; and W. J. Barrett, Newark, N. J., during the second half of the meeting.

Treasurer—W. I. Slichter, New York, N. Y.

Secretary—H. H. Henline, New York, N. Y.

By invitation, during discussion of a report of his committee, Chairman R. K. Honaman of the Committee on Public Relations.

Final Program Announced for IRE/AIEE Nucleonics Conference

A round-table discussion on "Evaluation of Radiation Hazards," and an address by Dr. Karl T. Compton, chairman of the Research and Development Board of the National Military Establishment, will highlight the 3-day second annual Joint Institute of Radio Engineers-AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine.

The final program for the conference, to be held October 31, November 1–2, at the Hotel Commodore in New York, N. Y., has just been released.

The round-table discussion, by a 4-man panel of scientific experts, and Dr. Compton's talk on "Co-operation Between the National Military Establishment and the Atomic Energy Commission," will be held the evening of November 1.

Simultaneously with the conference, the

Program for IRE/AIEE Conference on Electronic Instrumentation in Nucleonics and Medicine

Monday, October 31

Presiding: J. G. Reid, Jr., National Bureau of Standards

Morning

Low-Frequency Spectrography: Some Applications in Physiological Research. *Robert Rietz*, Bell Telephone Laboratories

High-Fidelity Electrocardiography. *S. R. Gilford*, National Bureau of Standards

Electrical Methods of Blood-Pressure Recording. *Frank Noble*, College of Electrical Engineering, Cornell University

Discussion by Professor William C. Ballard, College of Electrical Engineering, Cornell University

Afternoon

Stable D-C Amplifier for Biological Recording. *Dr. Harry Grundfest*, College of Physicians and Surgeons, Columbia University

Design of Cathode-Ray Oscillographs for Biological Applications. *Dr. W. A. Goodyear*, Cornell Medical College

A 25-Channel Recorder for Mapping Cortical Potential Fields. *Dr. John Lilly*, Johnson Foundation, Philadelphia, Pa.

Tuesday, November 1

Presiding: Dr. G. W. Dunlap, General Electric Company, Schenectady, N. Y.

Morning

Medical Applications of Ionizing Radiations. *Dr. Edith Quimby*, Radiological Research Laboratory, Columbia University

Dosage Measurements of Ionizing Radiations. *Dr. G. Failla*, Radiological Research Laboratory, Columbia University

Automatic Iso-dose Recorder. *Dr. G. J. Hine*, Sloan-Kettering Institute, New York, N. Y.

Afternoon

Measurement of Low Energy Beta Ray Emitters: Ionization Chambers. *Norman Baily*, Radiological Research Laboratory, Columbia University

Proportional Counters. *Dr. C. J. Borkowski*, Oak Ridge National Laboratory

Internal Gas Counting of C^{14} and H^3. *Dr. M. L. Eidinoff*, Queens College and the Sloan-Kettering Institute for Cancer Research, New York, N. Y.

Small Geiger Counters for Biological Applications. *Dr. Charles V. Robinson*, Harvard Medical School, Boston

Evening

A Round-table discussion on "Evaluation of Radiation Hazards" by a 4-man panel of scientific experts

An address by Dr. Karl T. Compton, Chairman of the Research and Development Board of the National Military Establishment

Wednesday, November 2

Presiding: Dr. Harner Selvidge, Bendix Aviation Corporation, Detroit, Mich.

Morning

Scintillation Counter Spectrometer. *P. R. Bell*, Oak Ridge National Laboratory

(*a*). **Energy Transfer in Scintillation Counting Systems.** *Dr. G. A. Morton*, RCA Laboratories, Princeton, N. J.

(*b*). **Phosphors for Scintillation Counters.** *R. H. Gillette*, Linde Air Products Laboratories, Tonawanda, N. Y.

Solids for Radiation Detection. *Dr. R. M. Lichtenstein*, General Electric Laboratory, Schenectady, N. Y.

Afternoon

Some Design Features of Electrical Counting Systems. *N. F. Moody*, National Research Council of Canada Atomic Energy Project

Desirable Improvements in Nuclear Instruments. *Dr. J. B. H. Kuper*, Brookhaven National Laboratory

Criteria in the Selection of Radio Isotopes for Industrial Use. *Dr. Eric Clark*, Traceriab, Boston, Mass.

first annual Nucleonics Manufacturers' Exhibit will be held on November 1 and 2 at the Hotel Commodore. This exhibit of nucleonics instrumentation is expected to be one of the largest ever held. Featured will be scalers, Geiger tubes, survey meters, scintillation counters, and industrial instrumentation utilizing radiation. Admission to the exhibit will be free to those registered at the conference.

Registration at the conference will cost $4. The advance registration fee is $3. Advance registration blanks can be obtained from R. D. Chipp, DuMont Television Network, 515 Madison Avenue, New York 22, N. Y.

Pacific General Meeting Establishes Record Attendance in San Francisco

The Pacific General Meeting, which was held in San Francisco, Calif., August 23–26, 1949, with headquarters in the Fairmont Hotel, offered an enlarged program well arranged, and in keeping with the industrial growth of the region. A total of 17 technical sessions, including two student sessions, was held during the four days of the meeting. In addition there was a general session, a luncheon meeting addressed by President Fairman, two executive meetings in the evening, and a student dinner meeting. A variety of inspection trips were taken to places closely related to the subject matter of papers on the program. On the social side, the banquet, golf tournament, and specially arranged trips and entertainment for the ladies offered ample opportunity to become better acquainted. The total attendance of 878 members, guests, and students, which established an all-time record for Pacific Coast meetings, exceeded the record attendance at San Diego of 589 two years ago representing a 49 per cent increase.

OPENING MEETING AND GENERAL SESSION

The meeting was opened by George C. Tenney, General Chairman, who introduced T. C. McFarland, Chairman of the San Francisco Section. Extending a cordial welcome to those present, Professor McFarland reviewed the technical program and directed attention to the six sessions and conferences in the field of power generation, transmission, and distribution, as well as the six sessions in the field of air transportation and the one session each in the fields of home heating, industry, communication, and nucleonics. He also called attention to the list of inspection trips which offered a variety of choice unequalled anywhere else. Referring to the students as engineers of the future, he welcomed them, the Counselors, and all who attended the meeting to the campus of the University of California at Berkeley.

An important address, "The Social and Economic Responsibilities of the Engineer," by W. C. Mullendore, President of the Southern California Edison Company, was given before the general session. In this inspirational address, Mr. Mullendore awakened the consciousness of complacent engineers and scientists who are deeply immersed in technical work to the imminent dangers of the rising tide of social and collectivist policies which threaten to destroy all technical advancements and our fundamental heritage of freedom. In this important address, published in full on pages 830–33 of this issue, the steps which should be taken in the crisis are suggested.

The speaker was introduced by Chairman Tenney, who referred to Mr. Mullendore's work with Herbert Hoover in food administration, as an author, as Past President of the Los Angeles Chamber of Commerce, and, prior to his appointment as President of the Southern California Edison Company, as general attorney and executive vice-president.

FAIRMAN ADDRESSES LUNCHEON MEETING

During a luncheon meeting on Tuesday, President James F. Fairman addressed the gathering on the subject of "Can Engineers Be Synchronized?" From a background of close personal contact with the organization of the engineering profession, President Fairman reviewed the steps taken in the work of the Subcommittee on Professional Activities of the AIEE Committee on Planning and Coordination since 1947. He believed that professional unity can be attained, but it will be a gradual process and he discussed possible courses of procedure during the interim. The full text of President Fairman's address was published in *Electrical Engineering* for September (*EE, Sep '49, pp 749–50*). During the luncheon, Chairman Tunney acted as toastmaster and introduced President Fairman as having served on almost every committee within the Institute. Chairman Tenney also introduced and paid tribute to the chairmen of the working committees of the Pacific General Meeting Committee.

BROADENING OF INSTITUTE ACTIVITIES

On Tuesday evening, a meeting of District, Section, national officers, and Student Counselors was held, principally to discuss the broadening of Institute activities, with Vice-President R. A. Hopkins presiding. To introduce the problem, President Fairman referred to the Smith resolution and the article entitled "Membership Views Sought on Institute Policy" (*EE, Jun '49, p 536*). He cited that he had seen the same type of problem arise and be debated in meetings of the Board of Directors from time to time, and he illustrated, by way of example, how the Institute had vacillated in a specific nontechnical activity until, due to the course of events, it was too late.

To determine the views of the membership on Institute policy, President Fairman referred to the ballot appearing with the article on page 890 of this issue, and explained that the AIEE would look to each of the Sections for a specific answer to the two proposals:

1. I favor adhering to technical fields.

Electrical World photo

Electrical World photo

(Left) A. Rusck (left) and B. Rathsman, both of the Swedish State Power Board, Stockholm, Sweden, here flank W. R. Johnson of the Pacific Gas and Electric Company at a Pacific Meeting power generation session at which all three presented outstanding papers. Mr. Johnson was session chairman

(Right) AIEE President James F. Fairman and General Chairman G. C. Tenney at the recent Pacific General Meeting in San Francisco

2. I favor expanding in nontechnical fields with substantially increased dues.

Walter C. Smith, who drafted the resolution, pointed out some of the difficulties which had been encountered in the past by the Institute and the Board of Directors in connection with professional activities. These difficulties were explained to the Section delegates during the Summer General Meeting in Swampscott, and were reported in *Electrical Engineering* for August 1949 under the subheading "Institute Policy" (*EE, Aug '49, p 700*). He further explained that almost everyone feels bound to try to preserve the Institute for its historical structure, but that many people, particularly those outside of the United States, are not interested in the nontechnical activities and would not pay additional dues. The number in this category is, of course, unknown. The officers should discuss the entire matter with the Sections this fall, and determine the views of the membership. In due course, an amendment to the Constitution to raise the dues might be obtained, but it would be a mistake to start the matter unless it is in accord with the views of the members.

In response to a question by Vice-President Hopkins in regard to the handling of professional activities in the National Society of Professional Engineers (NSPE), President Fairman explained the matter as outlined in the following.

These types of problems move very fast, and none of the existent organizations has the power to act on them promptly without the approvals of their Boards of Directors and committees. The National Society of Professional Engineers (NSPE) has a good organization on a local, state, and national level with a good lobby, and the straightforward way to expedite the handling of professional activities is through an organization designed to act for that purpose. In response to a question in regard to the number of members who are licensed and the possibility of losing members to NSPE, President Fairman replied that he did not believe that the Institute would lose many members because it takes four years to get a license, and one of the tenets of NSPE has always been that a member should be a member of at least one of the technical societies. The Institute has a large student enrollment and makes it easy to transfer to membership on completion of college work. From the return of approximately 17,000 Year Book cards, only about 40 per cent of the members are registered and considerably fewer than that are affiliated with NSPE.

Another question was raised concerning how the Institute, which has a membership comprised of both people who are in management and people who are employees, could properly represent employees in nontechnical activities matters. It was difficult to see how a composite membership could function in such matters.

Vice-President Hopkins inquired if other technical societies were paralleling AIEE organization in regard to professional activities. President Fairman responded that the Institute had invited joint meetings and that the results of the survey of the membership conducted by the Professional Activities Subcommittee of the Committee on Planning and Co-ordination was referred to Engineering Joint Council which had appointed a Committee on Unity. Invitations have been issued to 15 representative societies to meet and discuss the matter in October. It was not believed that the other societies are as yet doing anything in an organized way in regard to nontechnical activities. In conclusion, he explained that the special committee was trying to present the case impartially without selling anything, and to conduct open forums to get discussion, debate, and the opinions of members. As to sources of material, copies of the 1947 report of the Professional Activities Subcommittee could be obtained from headquarters. The article "Can Engineers Be Synchronized?" (*EE, Sep '49, pp 749–50*) reviews plans *B, C,* and *D*. In the present issue, the article entitled "To Be or Not to Be?" page 829, ties in with the Smith Resolution, and an article entitled "AIEE Board of Directors Seeks Membership Views on Institute Policy," which appears on page 890, includes a ballot. President Fairman urged that the Sections, after calling attention to those articles, should hold meetings in November, or not later than December, for the purpose of thoroughly discussing the problem and polling the views of the members.

With reference to the Summer and Pacific General Meeting in 1950 at Pasadena, Calif., F. Garrison, General Chairman, declared that it was the intent of his committee to have the technical program lighter and the meeting devoted more to social activities, provided the procedure meets with the desires of headquarters. D. I. Cone reported that the procedure was in keeping with the resolution in the bylaws to emphasize the social nature of the Summer Meeting.

Vice-President Hopkins referred to the fact that the Publicity Kit was a well-assembled and useful tool, and he inquired if it was customary to appoint a Publicity Committee in the Sections. Secretary Henline complimented the committee on the good discussion and interest in the meeting and remarked that District 8 has always had good meetings.

It was decided that the next meeting of the District Executive Committee (District 8) would be held in San Francisco on Friday, November 18.

STUDENT BRANCH OFFICERS AND COUNSELORS MEET

On Wednesday evening, a meeting of Student Branch officers and counselors was held at the University of California with Professor I. J. Sandorf presiding. Preceding the meeting, a dinner was held at the Faculty Club on the campus. The principal items on the agenda consisted of a report on the Student Relations Meeting at Swampscott, Joint AIEE-IRE Branch Operation, ways to interest Students in regular membership, student activities for the Summer and Pacific General Meeting in Pasadena next June, and Student Branch operation.

A summary report of the Student Relations Meeting at Swampscott was presented by R. M. Saunders, Counselor at the University of California. He reported that Past President Lee and President Fairman reviewed the plans for the organization of the engineering profession and that there was no longer a need for the list of Section speakers as there were a sufficient number of good speakers in the nearby Sections. Publicity kits were not believed to be required in the Branches and the meeting of the Counselors considered what to do about Students in nonaccredited institutions.

Future AIEE Meetings

Fall General Meeting
Netherland Plaza Hotel, Cincinnati, Ohio
October 17–21, 1949
(*Final date for submitting papers—closed*)

AIEE/IRE Conference on Electronic Instrumentation in Nucleonics and Medicine
Hotel Commodore, New York, N. Y.
October 31–November 2, 1949

Winter General Meeting
New York, N. Y.
January 30–February 3, 1950
(*Final date for submitting papers—November 1*)

AIEE Conference on Electric Power Supply for Industrial Plants
Pittsburgh, Pa.
April 1950

AIEE Conference on Meeting Load Demands With Limited Reserve
Pittsburgh, Pa.
April 1950

AIEE Conference on Electrical Engineering Problems in the Rubber and Plastics Industry
Akron, Ohio
April 1950

AIEE Conference on Electric Welding
Detroit, Mich.
April 5–7, 1950

North Eastern District Meeting
Providence, R. I.
April 26–28, 1950
(*Final date for submitting papers—January 26*)

Great Lakes District Meeting
Jackson, Mich.
May 11–12, 1950
(*Final date for submitting papers—February 10*)

Summer and Pacific General Meeting
Huntington Hotel, Pasadena, Calif.
June 12–16, 1950
(*Final date for submitting papers—March 14*)

1950 Fall General Meeting
Oklahoma City, Okla.
October 23–27, 1950
(*Final date for submitting paper—July 25*)

In regard to Joint AIEE-Institute of Radio Engineers Branch Operations at the University of California, Professor Saunders reported that everything was going smoothly with approximately 450 joint members and that they were attempting to get out a paper. One of the difficulties would be the large mailing list with some inactive members which increases the cost, and he believed that a dual counselorship would lead to difficulties.

At Stanford University, Professor W. G. Hoover, Counselor, reported that they are in their fourth year of effective Joint Branch operation. A great many of the students are interested in communication, but they are also members of the AIEE. Recently there has been a trend with a much greater percentage of students interested in the power field. Local dues of 50 cents and 25 cents are charged, and students can join the Branch without enrolling in the national organizations. A large part of the program is taken

Scene at the opening session of the AIEE Pacific General Meeting in San Francisco's Fairmont Hotel

up by the graduate students who have weekly seminars with highly technical speakers, and one of the problems is how to get the students who have heavy work programs to attend the meetings.

Several counselors of other Branches within the Districts reported that activities were getting underway without any apparent difficulties.

In regard to the AIEE Board of Directors policies on Joint Branches, President Fairman pointed out that a Past-President of the IRE is a Board member and that the Institute would, where desired, set up Joint Branches. The matter is not advertised and the Institute is not trying "to sell anything," but wishes to co-operate and to avoid creating any further friction. In the Sections, joint meetings and joint conferences are encouraged and have been working well. Mr. Fairman urged that everything be done to co-operate, and that counselors should not worry about the credit.

In regard to what the Sections are doing to interest students in regular membership, Professor T. C. McFarland, Chairman of the San Francisco Section, advocated setting up a Student Membership Committee to include all counselors in the District and which, at the time of graduation, would point out to the students the advantages of membership in the AIEE, and would encourage the students to apply for such membership. The San Francisco Section is active and very much interested in the students. For example, for the purposes of getting better acquainted, a meeting is held at which the students are introduced to the officers and later another meeting is held where the students in turn introduce the officers to other students. Secretary Henline explained that invitations to enrolled students to file applications for membership with application blanks are sent to students with the dues bill on May 1. If applications are not received, a second notice is sent out later drawing attention to the fact that the entrance fee will be waived if their applications for membership are received before the following March 1.

Consideration was given to the student activities for the Summer and Pacific General Meeting to be held in Pasadena next June. It was suggested that the meeting should not be too heavy on the technical side and a number of trips were suggested for the students which would entail some transportation difficulty as distances were as much as 20 to 40 miles. The suggestion was made it would be good to delegate a host to look after student housing as it was difficult to obtain information on hotels. Another counselor believed the Huntington Hotel might be expensive for students and he suggested that arrangements might be made at the California Institute of Technology for housing students if it was not commencement week. On the social side, a dance and some extra unattached girls was believed to be popular. Professor E. W. Schilling suggested that the views of the students in the vicinity of Pasadena should be obtained.

Each of the Students Branches reported on the high points of Branch activities during the past year. A variety of activities such as field trips, luncheon or evening meetings with student and guest speakers, prize paper presentations, and movies, more or less made up the types of programs, depending upon local conditions. Two or three of the Branches reported that meetings on employment opportunities were very popular. One of the Branches reported an interesting demonstration of the Tesla coil, another operates a radio station, and still another reported as operating a public address system which is rented by various departments and with which the Students have made a considerable amount of money. In several of the schools, it was reported that all-inclusive engineering councils, which are financed independently, have conducted activities, mainly of a social nature.

With respect to the tenure of service of counselors, Professor Saunders reported that at the University of California it was the custom for the counselor to have a 3-year term. The faculty believed that to ask the counselor to serve for a longer term would be an imposition which might hinder his own career. Professor Lewis of the University of Southern California advised that there had been three counselors during the years since the Branch was organized and that the burden should fall on others, which in a small school, is difficult. Counselors are selected by the students, with the approval of the Vice-President and appointment by the President. Professor Johnson believed that the matter should be very free and in the hands of the students. Others expressed the view that no rigid rules should be applied.

In response to a question, the Secretary of the Committee on Award of Institute Prizes, Edward C. Day, explained that in the case of the winners of the District Student Prize Paper Competition, the Vice-President of the District should notify Secretary Henline of the winners and a check and certificates will be prepared. New prize rules for AIEE technical papers, as approved by the Board of Directors, have been published (*EE, Sep '49, p 813*). Next year expenses, to the extent of nine cents a mile one way and a reasonable allowance for living expenses, will be paid from the Member-for-Life Fund to the winner of the District Student Prize Paper Competition in each of the even-numbered Districts to present his paper at the Summer and Pacific General Meeting in Pasadena.

THE BANQUET

Thursday evening, members and guests enjoyed a well-attended banquet which was held in the Fairmont Hotel. The Banquet and Entertainment Committee with I. W. Borda, Chairman, provided a good evening of entertainment with Armand Gerod, master of ceremonies, and music rendered by Jack Fischer and his orchestra. The winners of the Annual Golf Tournament were announced by W. L. Winter, Chairman of the Sports Committee.

GOLF TOURNAMENT

The Annual Golf Tournament and Competition for the John B. Fisken Cup was played over the course of the Peninsula Golf and Country Club on Thursday afternoon. The competition for the John B. Fisken Cup resulted in a tie between Homer L. Hussey of San Francisco and O. A. Gustavson also of San Francisco, and the cup was won by Mr. Hussey on a draw. The winners of the other prizes were as follows:

John M. Nelson, Seattle; high gross (one golf ball)
Homer L. Hussey, San Francisco; low net (electric sheet)
O. A. Gustafson, San Francisco; low net, class *A* (three golf balls)
P. O. Weston, Oakland, and J. P. Price, Fresno; tie—low net, class *B* (radio and steam iron)
T. B. Jones, San Francisco; low net, class *C* (Shave Master)
J. C. Hinkle, Portland; 2d low net, class *A* (three golf balls)
Peter Diederich, Glendale; 2d low net, class *B* (three golf balls)
C. R. Kingsbury, Seattle; 2d low net, class *C* (three golf balls)

Blind Bogey

Leland Stewart; first (Remington shaver)
L. G. Tandberg, Los Angeles; second (electric clock)
Dean Wilson, San Francisco; third (three golf balls)
A. M. Bishop, San Francisco; fourth (three golf balls)
R. J. Corfield, Salt Lake City; fifth (three golf balls)

POWER TRANSMISSION

Among the four sessions and one conference in the field of power generation, transmission, and distribution, one of the high spots was the presentation of a paper, "The Swedish 380-Kv System Now Under Construction," by A. Rusck of the Swedish State Power Board, and another paper, "Application of Series Capacitors and Double

Conductors in the Swedish Transmission System," by B. Rathsman, also of the Swedish State Power Board. After a review of the power transmission requirements of the country and a description of the existent 220-kv system, Mr. Rusck explained the steps leading to the decision to employ 380-kv for this 600-mile line. The voltage adopted resulted in a 15 per cent lower cost per kilowatt transmitted than in a 220-kv line. Also, the decision to employ a solidly grounded neutral instead of Peterson Coils and the lower cost of less complicated transformer windings resulted in other savings. The factors leading to the decision to employ series capacitors and double conductors were described by Mr. Rathsman. He explained that double conductors offered most of the advantages of bundle conductors with a simplified construction and at a lower cost. A the conclusion of the session, a motion picture of the construction of the 380-kv line was shown.

The papers on the Swedish 380-kv transmission system dovetailed in very well with a paper on "Postwar Planning for High-Voltage Transmission in Northern California," by W. R. Johnson, who also presided at the session. Mr. Johnson drew an interesting comparison between Sweden and California, indicating that Sweden had a population of 7,000,000 as compared with 10,000,000 for California. The area for Sweden is 173,000 square miles as compared with 159,000 square miles for California. The precipitation in Sweden is 22 to 25 inches per year. Among other discussions, P. L. Bellaschi commented that the economic advantages of the Swedish system were very apparent. He drew attention to the 230-kv system in the Northwest as well as the Hoover Dam, Los Angeles transmission, which was comparable, and drew the conclusion that the higher voltage systems will perhaps have application in Canada and South America. The two papers were also discussed by Professor E. C. Starr who complimented the authors for having done a very fine engineering job for conditions as they exist in Sweden by the combination choice of the higher voltage, the application of series capacitors, and the adoption of double conductors which lower the transfer reactance of the line. He raised the question as to whether the problem of icing had been taken into consideration, and E. L. Kanouse also inquired as to whether the tower design for double conductors contained an element for broken conductors. In the closure, Mr. Rusck said that both broken conductors and icing had been taken into consideration in the tower design.

CONFERENCE ON CALCULATING BOARD OPERATION

Thursday morning, a conference meeting on calculating Board operation was held in the Pacific Gas and Electric Company building, with Dr. A. Tilles presiding. Conference presentations were made by representatives familiar with the operation of the four calculating boards in the Pacific Coast area as follows.

B. V. Hoard of the Bonneville Power Administration gave an outline of the procedure for stability study by the graphic method.

E. G. Olmsted of the Department of Water and Power, City of Los Angeles, discussed the network calculator operation on heir system.

H. R. Perry of the Pacific Gas and Electric Company discussed the forms which that company has devised for keeping data and illustrated his talk with samples. He also mentioned an improvement made in their board by shortening the red pointers on the generator instruments.

W. A. Morgan of the Bureau of Reclamation at Denver described the a-c network analyzer used on their system. He explained that instead of using 20 forms, they used only six, and that tags are available which are stuck on cords to help identify the busses.

Attention was drawn to a fifth calculating board on the West Coast by L. L. Grandi of the University of California at Los Angeles who advised that a General Electric analyzer with six generators had just been installed at the university.

W. F. Enns also reported that the Portland General Electric Company has had a calculator since 1943, and that he had written a paper on the operation of the calculating board.

A paper on the network analyzer operations at the Public Service Electric and Gas Company of Newark, N. J., was read by J. W. Buchwald of the Pacific Gas and Electric Company, as well as a letter from L. M. Haupt, Supervisor of the Network Calculator Laboratory at Texas Agricultural and Mechanical Research Foundation. Letters were received from other engineers who were unable to be present, but who were interested in network calculators as follows: H. K. Sels, R. B. Squires, P. O. Bobo, J. R. Eaton, and E. B. Eggers.

A communication was received from H. P. Peters, Supervisor-in-Charge of the a-c network calculator of the Georgia Institute of Technology which suggested that calculator operators should be organized for the purpose of exchanging information. Those in attendance agreed that some kind of organization might be valuable.

AIR TRANSPORTATION

Four technical sessions and two conferences were held in the field of air transportation, and papers were presented which dealt with the design of new apparatus, the electric systems, and protective equipment. The conferences provided a time and place for the continuation of the discussion carried over from the three previous sessions. They also provided an opportunity for the discussion of timely problems that arose since the program was planned.

In the conference on aircraft electric system protection held on Thursday morning, a paper was presented on "Philosophy of Aircraft Electric System Protection," by L. R. Larson of the Naval Research Laboratory. Following the presentation, a lively discussion ensued on the subject of protection from, and prevention of, arcing faults to ground.

In the afternoon, a conference was held on aircraft electric systems at which a paper was presented on "A New Approach to Aircraft Electric Systems," by E. F. Kotnik of the Consolidated Vultee Aircraft Corporation. An interesting discussion took place concerning the possibility of designing the electric generators as an integral part of the aircraft engines.

The active participation of the air-line operators, the military services, the air frame and accessory manufacturers in discussion at these meetings indicated the enthusiastic interest in the important problems of design, installation, and maintenance of electric equipment and systems for modern aircraft. Without these electric systems, modern aircraft cannot complete its flight mission. The interest and response to the conferences was so successful that the practice will be continued.

NUCLEAR POWER PLANT POSSIBILITIES

Among the conference papers presented at a nucleonics session, the one on "The Outlook for the Nuclear Power Plan," by Dr. I. Perlman of the University of California Radiation Laboratory aroused considerable interest. Dr. Perlman stated that any predictions as to when to expect a nuclear power plant or a going nuclear power industry are hard to make since there are still too many unknowns; however, in reply to the questions regarding an approximate time, he said that in six or ten years there may be practical applications. There are both hopeful and pessimistic sides to the picture. Some scientists paint a rosy picture of its future as there is plenty of uranium available and it is easily transportable to locations where power is unavailable. To illustrate, he displayed a small cube of uranium metal which could produce ten million kilowatt-hours, or enough power to supply a city the size of San Francisco, Calif., for one day. Uranium is not terribly rare; there are from two to four parts per million in average rock.

Doctor Perlman outlined the principles of extracting energy from the uranium, the chain reaction, and the means of controlling the power. He discussed the importance of making plutonium, the recently discovered element not known to exist in nature.

One of the outstanding problems is in the metallurgical and ceramic fields since it is necessary to find new materials which can stand the high temperatures and which are noncorrosive as the equipment must run without repair for the lifetime of the plant. Likewise, there is the chemical problem of reclaiming unburned material, and the problem of how to operate the power pile as a breeder so as to make all of the uranium undergo fission. However, even if these problems remain unsolved for the present, it is possible to operate a nuclear power plant, but not in the most efficient manner. The solution for the problems will be found by starting to build power piles and then through experience it will be possible to construct a power plant which will be practical.

STUDENT PROGRAM

Two student sessions were held on Friday, one in the morning at the Fairmont Hotel, and the other in the afternoon at the University of California. In the evening a dinner meeting was held at which an address, "An Electrical Man's Observations in Italy," was given by R. E. Fisher of the Bechtel Corporation, San Francisco. Papers were presented by the students as follows:

"Topographic Presentation Radar." Walter Hirschberg, California Institute of Technology

"A Magnetostriction Oscillator for the Production of Supersonic Energy." James L. Van Meter, Washington State College. Presented by D. DeHart

"A Static Frequency Converter." James Haynes,

University of Idaho. Presented by Don La Proy

"Use of the Electrolytic Tank to Study Magnetic Circuits." Jerome T. Goothertz, University of California

"Hydroelectric Power in Alaska." Robert L. Kelley, University of Washington. Presented by R. A. Maurer

"High-Frequency Heating of Dielectric Material." Raymond C. Johnson and Wayne F. Mulcock, University of Utah. Presented by Mr. Johnson

"A Linear A-C Voltmeter for Power Circuits." Bechtel N. Sylvain, Montana State College

"An Analogue Computer for Transient Stability Limits of Power Systems." Edward L. Cordell, University of California

"Design of a Tit-Tat-Toe Machine." Robert Haufe, California Institute of Technology

"A Wartime Computer in a College Laboratory." Jerry M. Roberts, University of Nevada. Presented by Charles Tam

"Shanghi Power Company's Transmission and Distribution System." Peter S. Komor, University of California

"Protection of Polyphase Machines From Unbalanced Voltages." J. E. Filice and J. N. Ylarraz, University of Santa Clara

"A Wave-Form Synthesizer and Analyzer." Rodney North, University of Southern California

LADIES ENTERTAINMENT

In addition to the banquet on Thursday evening, three outstanding functions were arranged for the ladies. An informal tea was held at the Fairmont Hotel. An outing was taken to Palo Alto and Stanford University with a specially arranged luncheon at a unique tea shop. A tour was made of San Francisco, including a trip to Fisherman's Wharf, a boat cruise on beautiful San Francisco Bay, and a visit to Chinatown where luncheon was served at the exotic Cathay House.

COMMITTEES

Members of the Pacific General Meeting Committee which made the excellent arrangements were as follows:

G. C. Tenney, *Chairman;* C. E. Baugh, *Vice-Chairman;* J. A. Robinson, *Secretary;* W. F. Poynter, *Treasurer;* H. R. Brown, L. A. Buese, H. A. Cordes, B. Cozzens, M. M. Ewell, L. R. Gamble, C. P. Garman, G. H. Groh, O. A. Gustafson, J. A. Hale, C. M. Hart, N. B. Hinson, O. W. Hurd, T. Ingledow, T. Jordan, C. W. Keller, L. M. Klauber, S. E. McArthur, J. H. Polhemus, D. D. Smalley, J. H. Steede, C. F. Terrell

Chairmen of the subcommittees were the following:

J. L. Buckley, *Registration;* D. I. Anzini, *Program;* R. O. Boemer, *Hotel;* I. W. Borda, *Entertainment* and *Reception;* Mrs. G. C. Tenney, *Hostess;* W. J. Warren, *Student Activities;* W. R. Nodder, *Trips and Local Transportation;* H. C. Verwoert, *Transportation;* W. L. Winter, *Sports;* R. Bollaert, *Publicity*

AIEE Officers to Be Nominated for 1950 Election

For the nomination of officers to be voted upon in the spring of 1950, the AIEE Nominating Committee will meet in New York, N. Y., in January 1950. The officers to be elected are: a president, a treasurer, three directors, and five vice-presidents, one from each of the odd-numbered geographical Districts. Fellows only are eligible for the offices of president, and Members and Fellows for the offices of vice-president, director, and treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the committee, all suggestions must be received by the secretary of the committee at Institute headquarters, not later than December 15, 1949.

In accordance with the provisions in the constitution and bylaws, quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way.

Constitution

28. There shall be constituted each year a Nominating Committee consisting of one representative of each geographical District, elected by its executive committee, and other members chosen by and from the Board of Directors not exceeding in number the number of geographical Districts; all to be selected when and as provided in the bylaws. The Secretary of the Institute shall be the secretary of the Nominating Committee, without voting power.

29. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The Nominating Committee shall name on or before January 31 of each year, one or more candidates for president, treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the Nominating Committee when and as provided in the bylaws; otherwise the Nominating Committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

Sec. 21. During September of each year, the secretary of the Nominating Committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each district must select a member of that District to serve as a member of the Nominating Committee, and shall by December 15, notify the secretary of the Nominating Committee of the name of the members elected.

During September of each year, the secretary of the Nominating Committee shall notify the chairman of the executive Committee of each geographical District in which there is or will be during the year a vacancy in the office of vice-president, that by December fifteenth of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the Nominating Committee.

Between October first and December fifteenth of each year, the Board of Directors shall choose five of its members to serve on the Nominating Committee and shall notify the secretary of that committee of the names so selected and shall also notify the five members selected.

The secretary of the Nominating Committee shall give the fifteen members so selected not less than ten days' notice of the first meeting of the committee, which shall be held not later than January thirty-first. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. To insure that full consideration be given to all suggestions from the general membership, they must be in the hands of the secretary of the committee by December fifteenth. The nominations as made by the Nominating Committee shall be published in the March issue of *Electrical Engineering*, or otherwise mailed to the Institute membership not later than the first week in March.

Independent nominations may be made in accordance with provisions in article VI, section 31, of the constitution and section 22 of the bylaws, which are quoted below:

Constitution

31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

Bylaws

Sec. 22. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (constitution), must be received by the secretary of the Nominating Committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the Nominating Committee in accordance with article VI of the constitution and sent by the secretary to all qualified voters on or before April 15 of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline
Secretary

North West District Executive Committee Meets

Sixteen officers of the North West District, as well as President James F. Fairman, attended a meeting of the District 9 Executive Committee held last August 29, Vice-President Richard McKay presiding. One of the resolutions passed was that the Portland Section be host to the Pacific General Meeting in 1951.

In another motion passed, it was decided that the selection of candidates for the office of Vice-President be made on the basis of rotation among the Sections as in the past. In this connection, the Utah Section was invited to select a candidate and to advise Vice-President McKay of their choice by October 1.

The status of the Vancouver Section came up for discussion. The Executive Committee went on record as favoring a transfer of this Section to District 9, provided a favorable basis could be worked out for such an arrangement.

The District 9 officers also decided that the Richland Section should select the delegate representing that District on the 1950 National Nominating Committee.

New York Section to Hear Architect. Ralph T. Walker, well-known architect, Senior Partner of Voorhees Walker Foley and Smith, and President of the American Institute of Architects, will speak before the AIEE New York Section at a General Section Meeting to be held on October 19, 1949. His subject will be "The Purpose of Light."

COMMITTEE NOTES •

Editor's Note: This department has been created for the convenience of the various AIEE technical committees. It will include brief news reports of committee activities and proposed plans for such projects as special technical conferences and sessions at general meetings. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Group

Committee on Marine Transportation. (*O. A. Wilde, Chairman; E. C. Alger, Vice-Chairman; W. N. Zippler, Secretary.*) Notable among the varied activities of several subcommittees of the Committee on Marine Transportation are the following:

Subcommittee 2, Power Applications (*L. M.*

Goldsmith, Chairman) has prepared recommended Standards for test of voltage drops in shipboard electric power and lighting circuits. The recommendations have been adopted by the Marine Technical Committee for inclusion in Standard 45, "Recommended Practice for Electric Installations on Shipboard."

Subcommittee 3, Wires and Cables (*W. N. Zippler, Chairman*) proposed and the main committee agreed that asbestos can be applied in the construction of AVC cables (asbestos-varnished-cambric) in either tape or felted form.

Subcommittee 4, Switchboard and Controls (*H. C. Coleman, Chairman*) prepared revised recommendations for motor control auxiliary circuits to improve the safety of operation and repair of equipment. Other recommendations were made to co-ordinate the protection of motor control equipment with cable protection. These recommendations were adopted by the Marine Committee for inclusion in Standard 45.

Subcommittee 7, Communications and Alarms (*W. H. Reed, Chairman*) is reviewing designations of signal and communication systems, as recommended in Standard 45, to insure agreement, in so far as is practicable, with JAN and ASA Standards.

Editing Subcommittee (*W. N. Zippler, Chairman*) is preparing an addendum to Standard 45 covering important additions or changes found desirable since its issue. The addendum will be submitted to the Standards Committee of the Institute for approval for inclusion in copies of Standard 45. It is intended that the addendum be made available to present possessors of the latest issue of Standard 45. Other subcommittees are continuing review of the sections of Standard 45 under their cognizance, giving consideration to comments they received from users of the Standard.

Industry Group

Joint Subcommittee on Servomechanisms, 1948–49. (*G. S. Brown, Chairman; H. J. Marcy, Secretary.*) This subcommittee, operating under the sponsorship of the Committees on Instruments and Measurements, Basic Sciences, and Industrial Control, rounded out an effective year with strong technical representation at the Winter and Summer General Meetings. The Subcommittee on Terminology and Definitions, under the chairmanship of Dr. S. W. Herwald, with Vice-Chairman F. E. Crever, is making considerable progress on this difficult task. Recommendations to upgrade the subcommittee to full committee status were approved by the Board of Directors at its meeting of June 23. A committee, composed of W. R. Clark, C. Concordia, W. Richter, G. W. Heumann, and G. S. Brown, was appointed to decide upon title, scope, and intercommittee co-operation. This new committee will be assigned to the Industry Group. Consideration has been given to the question of conducting a conference on feedback-control devices (regulators, governors, and servomechanisms) jointly with other interested committees. It is not expected that this conference can be scheduled prior to next spring.

Subcommittee on Pulp and Paper Industry of Committee on General Industry Applications. (*G. W. Knapp, Chairman.*) This subcommittee has undertaken a very interesting and important task, namely, the preparation of comprehensive reports summarizing electrical engineering practices for driving paper winders and supercalenders. The members of the subcommittee have pooled their joint resources, and have exchanged data heretofore available to individual companies only.

Reports on the subjects of electric equipment for paper mill winders and paper mill supercalenders were presented and discussed at the Summer General Meeting. The subcommittee plans to continue and to expand this line of activity and during the coming year contemplates a session at the Fall General Meeting, a conference in the northwest, jointly with local AIEE Sections, and a conference in the southeast, also jointly with local Sections.

Power Group

Committee on Transformers. (*J. B. Hodtum, Chairman; F. J. Vogel, Vice-Chairman; M. K. Brown, Secretary.*) The Committee on Transformers is now fully organized for the 1949–1950 sessions. Practically all working groups remain unchanged except for a few minor additions. The general membership has been increased to obtain a wider representation of the AIEE Districts.

The Subcommittee on "Proposed AIEE Guides for Operation and Maintenance of Dry-Type Transformers With Class *B* Insulation," has issued a report to the Apparatus Standards Committee of National Electrical Manufacturers Association and to the Electrical Equipment Committee of Edison Electric Institute for general comments. These comments will be greatly appreciated since it is the desire of the Transformer Committee to make these guides as useful as possible.

The Instrument Transformer Subcommittee has issued a letter-ballot to the members of the Transformer Committee asking for approval of the "Guides for Grounding Instrument Transformer Secondary Circuits and Cases," or for comments which might add to their usefulness.

The organization of a subcommittee to study "Methods of Making Heat Runs," is now completed. This group will investigate the present Standards for conducting temperature tests on transformers. The work will include study of the existing methods and will expand them to include temperature tests on dry-type transformers. It is the goal of this subcommittee to have a report available for the Summer and Pacific General Meeting at Pasadena in 1950.

Sheaths and Coverings Subcommittee of Insulated Conductor Committee. (*G. H. Fiedler, Chairman.*) Included in the scope of the Sheaths and Coverings Subcommittee are lead and lead alloys, jacket materials, electrolysis and corrosion (including liaison with NACE), protective coverings for lead sheaths and armors.

A summary prepared by C. E. Betzer, Commonwealth Edison Company, describes the work which has been done to date on lead and lead-alloy sheathings by the various manufacturers and gives a brief review on the work in progress. Discussions of tests by users are included as well as a bibliography of the work done with the University of Illinois. The publication is complete in the minutes of the third committee meeting held in New York, N. Y., December 2–3, 1948.

Questionnaires on protective coverings for lead sheaths have been submitted to both manufacturers and users of cables with protective coverings. A very good response has been obtained and valuable and interesting information accumulated. Consideration is being made for wider distribution of the information received.

Several companies are carrying on service tests on lead sheathing but to date sufficient data have not been obtained to provide material for a paper.

Cable Characteristics Subcommittee of Insulated Conductor Committee. (*W. A. Del Mar, Chairman.*) The Cable Characteristics Subcommittee has completed a theoretical study designed to enable engineers to make economic comparisons of pipe cables and duct cables on the basis of equal current-carrying capacity and equal thermal resistivity of the soil. Three papers have been presented on this subject, two by J. H. Neher (49-2, 49-134) and one by A. S. Mickley (49-83). This project is considered complete until experimental data become available and make a reopening advisable. The theoretical work will give a framework on which to place the experimental data and give the latter a broad significance.

A working group headed by C. T. Hatcher is developing methods of calculating the hydraulics of oil-filled pipe-cable systems. A study of vertical risers has been completed and a report is being prepared for presentation to the main committee. A working group headed by E. R. Thomas is collecting data on zero-sequence impedance of cables. A group of mathematical papers on transients in oil-filled cable is under consideration.

The a-c resistance of cables in steel pipes is being studied by an AEIC group in collaboration with manufacturers. It is expected that this work will eventuate in at least one AIEE paper. A theoretical paper (49-135) on this subject by L. Meyerhoff and G. S. Eager, Jr., was presented at the Summer General Meeting and like the Neher and Mickley papers will serve as a framework for generalizing the experimental data which we expect to receive.

AIEE PERSONALITIES . . . . .

Vannevar Bush (A'15, M'19, F'24), President, Carnegie Institution of Washington, Washington, D. C., has been elected an Honorary Member of the AIEE by the Board of Directors of the Institute. An alumnus of Tufts College, from which he received bachelor and master of science degrees in 1913, his first position was with the General Electric Company. From 1914 to 1915, Dr. Bush was an instructor in mathematics at his alma mater, being advanced to Assistant Professor of electrical engineering in 1916.

Vannevar Bush

K. B. McEachron

W. J. Barrett

F. M. Farmer

In the latter year, he received doctor of engineering degrees from the Massachusetts Institute of Technology and Harvard University. Research on submarine detection with a special board on submarine devices of the United States Navy occupied him from 1917 to 1918. In 1919, he began a 20-year association with the Massachusetts Institute of Technology, Cambridge, as Associate Professor of electric power transmission. He was named Professor in 1923 and Vice-President and Dean of Engineering nine years later. He became President of the Carnegie Insitution of Washington in 1939. Extremely active in government during World War II, he has been a member of the National Advisory Committee for Aeronautics and was its Chairman from 1939 to 1941. In addition, he has been Chairman of the National Defense Research Committee, 1940–41. He was appointed Director of the Office of Scientific Research and Development in 1941, Chairman of the Joint Committee on New Weapons and Equipment of the Joint United States Chiefs of Staff in 1942, and was Chairman of the Research and Development Board, 1947–48. Dr. Bush's accomplishments in the fields of scientific research and teaching have been recognized in that he has received 17 honorary degrees from educational institutions and 13 medals from engineering societies and other organizations. Some of the latter include: the Levy Medal of the Franklin Institute in 1928; the AIEE Lamme (1935) and Edison (1943) Medals; the United States Distinguished Service Medal, 1945; the Washington Award, 1946; the Hoover Medal, 1947; and the Industrial Research Medal, 1949. Noted as the builder of the differential analyzer and the author of numerous technical books and papers, Dr. Bush is a member of the American Association for the Advancement of Science, the American Physical Society, the National Academy of Sciences, the American Philosophical Society, Tau Beta Pi, Kappa Eta Kappa, Sigma Xi, and Phi Beta Kappa. A Director of the Institute, 1937–41, Dr. Bush has served on many AIEE committees, some of these being: Transmission and Distribution; Research; Technical Program; and Coordination of Institute Activities.

K. B. McEachron (A'14, F'37), Chairman of the AIEE Publications Committee, has been named Manager of Engineering for the General Electric Company's Transformer and Allied Product Divisions at Pittsfield, Mass. Formerly Assistant Manager of Engineering for the Divisions, Dr. McEachron succeeds **F. F. Brand** (A'10, F'39, Member-for-Life) who has retired from the company after 47 years of service. A graduate of Ohio Northern University in 1913 with bachelor of science degrees in electrical engineering and mechanical engineering, Dr. McEachron joined General Electric as a student engineer on the Test Course that same year. He returned to Ohio Northern University in 1914 as an instructor in electrical engineering and four years later became an instructor and a research associate at the Engineering Experiment Station of Purdue University, where he received a master of science degree in electrical engineering two years later. He returned to General Electric in 1922 to take charge of research in the Lightning Arrester Engineering Department at Pittsfield, the position he held until his appointment as engineer in charge of the High-Voltage Engineering Laboratory. For the development of Thyrite, a material used for lightning arresters, Dr. McEachron received the Charles A. Coffin Award, the General Electric Company's highest award to any employee, and the Longstreth Medal of the Franklin Institute. Under his direction, the 10,000,000-volt artificial lightning generator used at the New York World's Fair was developed and the annual Empire State Building lightning studies were begun. He is coauthor of the book "Playing With Lightning," and more recently author of "Lightning and Lightning Protection," for the Encyclopedia Britannica. He is a member of the Board of Registration of Professional Engineers in Massachusetts, and the Panel of the National Research and Development Board. A Director of the Institute, 1936–40 and Vice-President of District 1, 1942–44, Dr. McEachron has served on the following committees: Basic Sciences; Protective Devices; Edison Medal; Technical Program; Executive; Standards; Board of Examiners; Lamme Medal; Transfers; and the Special Committee on Registration of Engineers.

Walter J. Barrett (M'36), Electrical Coordination Engineer, New Jersey Bell Telephone Company, Newark, N. J., has been elected a Director of the Institute. Born January 10, 1899, in Brooklyn, N. Y., he is a cum laude graduate in electrical engineering of the Polytechnic Institute of Brooklyn. After receiving his degree in 1920, he joined the American Telephone and Telegraph Company, in New York, N. Y., where he did traffic engineering work. The following year he was transferred to Cleveland, having similar duties with the Ohio Bell Telephone Company. In 1922, Mr. Barrett returned to New York. There, working for the American Telephone and Telegraph Company, he did transmission engineering and engaged in electrical co-ordination studies, until he accepted his present position in 1930 with New Jersey Bell. Mr. Barrett is Chairman of the Special Committee to Survey Building Needs of the Institute and Chairman of the Special Committee to Study Headquarters Equipment and Methods. A member of the Sections Committee, he served on the National Nominating Committee in 1948 and is a director and member of the Finance Committee. Mr. Barrett was Chairman of the New York Section, 1947–48, and Secretary of District 3, 1948–49. Mr. Barrett is a member of Tau Beta Pi.

F. M. Farmer (A'02, M'12, F'13), who has been associated with the Electrical Testing Laboratories since 1903, has been named President of that organization, succeeding the late P. S. Millar. He was named Chief Engineer in 1911 and Vice-President of the Laboratories in 1929. An 1899 mechanical engineering alumnus of Cornell University, he worked in the Testing Department of General Electric, Schenectady, N. Y., for 18 months after his graduation. Then, he was employed by the United States Navy Yard in Brooklyn, N. Y., as an inspector in the Bureau of Equipment. During the years 1902–06, he was an instructor in electrical measurements and physics in the Night School of Science, Cooper Union Institute, New York, N. Y. Mr. Farmer has been extremely active in engineering organizations. He is a member of the American Association for the Advancement of Science and the American Society of Mechanical Engineers. He is a past-president of the AIEE (1939–40), the American Society for Testing Materials, the American Welding Society, and the United Engineering Trustees. He has been Chairman of the Engineering Foundation and the American Standards Association Standards Council. Mr. Farmer served as Director of the Institute, 1934–38 and Vice-President, 1938–39. Some of the committees on which he has served are: Standards; Board of Examiners; Transmission and Distribution; Electric Welding; Research; Technical Program; Award of Institute Prizes; Executive; Edison Medal; Finance; Planning Co-ordination; Publication; and Constitution and Bylaws. Mr. Farmer is a Member-for-Life.

S. A. Schelkunoff (M '34) of the Physical Research Department, Bell Telephone Laboratories, New York, N. Y., has been awarded the Stuart Ballantine Medal of the Franklin Institute, Philadelphia, Pa., for his contributions to the extension of the electromagnetic wave theory. Dr. Schelkunoff received his bachelor of arts and master of arts degrees from Washington State College in 1923, and in the following year joined the Bell Laboratories. His doctor of philosophy degree was earned at Columbia University. Dr. Schelkunoff has been active in the teaching field as well as on the technical staff of Bell Laboratories, having taught at Washington State College, in the Graduate School of Mathematical Mechanics at Brown University, and at New York University. During the second World War, he was Consultant on Wave Propagation at the United States Sound and Radio Laboratory at San Diego, Calif. He is now Consultant on Electromagnetic Theory at the Bell Laboratories. A number of books and papers on mathematics and electromagnetic theory have been written by Dr. Schelkunoff, one of which, "Antennas," is being published this year. He is a member of the American Mathematics Association, the American Association for the Advancement of Science, and the Institute of Radio Engineers. The latter organization awarded him its Morris Liebman Memorial Prize in 1942. The Stuart Ballantine award, founded in 1942, includes a gold medal and certificate given in recognition of outstanding achievement in the fields of communication and reconnaissance which employ electromagnetic radiation.

A. S. Fitzgerald (M '27), electrical research engineer of San Francisco, Calif., has been awarded the Louis Edward Levy Medal of the Franklin Institute. The award is in recognition of the exceptionally clear manner in which Mr. Fitzgerald presented, in papers appearing in the Franklin Institute Journal, the design criteria of nonelectric amplifiers. When he came to the United States from England, his native country, in 1924, he entered the employ of the General Electric Company. He was instrumental in the development and installation of the first carrier-current relay system in the United States. Mr. Fitzgerald later joined RCA Victor in Camden, N. J., and, in 1932, he launched independent research, first at Swarthmore College, Swarthmore, Pa., and afterward, at Haverford College, Haverford, Pa. The Louis Edward Levy Medal is presented to an author of a paper of special merit appearing in the Journal of the Franklin Institute. Mr. Fitzgerald has published 16 papers in the Journal.

J. V. B. Duer (A '15, F '29), retired railroad executive residing in Fairfield, Conn., has been awarded the George R. Henderson Medal of the Franklin Institute for his resourcefulness and contributions in the coordination of railroad engineering matters, especially in the electrification of the Pennsylvania Railroad. A 1903 graduate of the Stevens Institute of Technology, he began railroad work in 1906 with the Long Island Railroad. At the time of his retirement in 1947, he was Vice-President in Charge of Operation. One of his acts was the supervision of the changeover of the Pennsylvania Railroad main-line, extending from New York, N. Y., to Harrisburg, Pa., and Washington, D. C., from steam to electric operation. The Henderson Medal was founded in 1924 and is awarded for meritorious achievements in the field of railway engineering. Mr. Duer is a Member-for-Life.

J. C. Parker (A '04, F '12) has resigned from his position as Vice-President of the Consolidated Edison Company of New York (N. Y.), Inc. Mr. Parker joined the former Brooklyn (N. Y.) Edison Company, a subsidiary of Consolidated, in 1922, and later became Vice-President in charge of all Brooklyn Edison engineering. From 1932 to 1936, he served as President of that company. When it was merged into Consolidated Edison in 1936, he became a vice-president in the parent company and was responsible for the departments engaged in research and development. Mr. Parker was President of the AIEE during the 1938–39 term and Vice-President, 1921-22. At present, he is on the United States Executive Committee of the World Power Conference.

N. B. Gussett (M '37, F '48) has resigned from his post as acting General Manager of the City Public Service Board, San Antonio, Tex., to accept the presidency of the Iowa Power and Light Company, Des Moines. He joined the San Antonio Public Service Company in 1925 and was made Assistant Engineer. In 1935, he became Manager of all electric operations except those in the metropolitan area. Five years later, Mr. Gusset entered the Army as a Captain in the Engineer Corps, later being promoted to Lieutenant Colonel. For his military service, he was awarded the Legion of Merit.

J. R. James (A '37) has been elected President of the James G. Biddle Company, Philadelphia, Pa. He had been Vice-President and Treasurer since 1944, having joined the company in 1930. Additional appointments made at the same time were: **A. Q. Lange** (A '45) to Technical Sales Engineer; **T. B. Whitson** (A '28) to Director of Engineering; and **E. B. Curdts** (A '25, M '29) to Assistant Director of Engineering. Mr. Lange has been associated with the company for more than 20 years in a sales capacity. Mr. Whitson formerly was in charge of advertising, and Mr. Curdts joined the firm in 1944 as Application Engineer.

H. P. Seelye (A '19, F '43) has been appointed Chief Engineer of the Engineering Department, Detroit (Mich.) Edison Company. **E. R. Moore** (M '40) has been designated Assistant Chief Engineer of the department. The utility recently changed the name of the System Engineering group to Engineering Department. With the company since 1916, Mr. Seelye previously was Chief Electrical Engineer in charge of the Electrical Section of the Engineering Division. Mr. Moore, who joined the firm in 1926, formerly held the post of Assistant to the Chief Engineer of the System.

N. M. DuChemin (A '29, M '47), until recently Manager of the General Electric Company's Meter and Instrument Divisions at Lynn, Mass., has become Assistant General Manager of the Apparatus Department. Mr. DuChemin has been with General Electric for 45 years.

OBITUARY

Arthur Everitt Val Davies (A '21), formerly a consulting engineer, Johannesburg, Union of South Africa, died July 6, 1949. Born in 1883 in Grahamstown, South Africa, he was a graduate of the Royal Technical College, Glasgow, Scotland. From 1900 to 1905 he held an engineering apprenticeship with the Glasgow firms of Messrs. Mavor and Coulson and Messrs. Duncan Stewart and Company. In 1906, he worked as a shift engineer for the Mexican Power and Light Company. The following year, he went to Johannesburg. During the next three years, he worked on projects related to gas engines, printing machinery, and gold-mine apparatus. From 1910 to 1912, he was Resident Engineer for the Electricity Supply Concession, Delagoa Bay, East Africa. Next, he joined the Victoria Falls Power Company, where he was made responsible for the maintenance and repair of all generating-plant and transformer equipment. In 1918, Mr. Val Davies was designated Assistant City Electrical Engineer of the Corporation of the City of Capetown. He opened a consulting engineering practice in Johannesburg in 1923 which he operated for 22 years. Mr. Val Davies was a member of the Institution of Electrical Engineers and the South African Institute of Electrical Engineers. In 1919, he was named External Examiner in Electrical Engineering in the University of Capetown.

Lynn Sumner Goodman (A '11, M '27), former Assistant to the President, Boston (Mass.) Edison Company, died July 27, 1949, at Wellesley, Mass. A 1908 graduate of the Massachusetts Institute of Technology (he received a bachelor of science degree in electrical engineering), his first engineering position was with the consulting firm of D. C. and William B. Jackson, of Boston, Mass., and Chicago, Ill. There, he was Field Engineer in charge of inventories and examinations of light and power, railway, telephone, and gas utilities. In 1918, he joined the American International Shipbuilding Corporation at Hog Island, Pa., being designated Executive Assistant. One of his duties was the drawing up and administering of subcontracts. It was in 1920 that he became associated with Boston Edison, where he was named to the position of Assistant Superintendent of the Statistical Bureau. Here, he engaged in studies of financial operations and futures. Later, he was promoted to Superintendent of that bureau, and in 1936 he was appointed Clerk and Assistant Treasurer. Two years later, he became Assistant to the President, a post from which he retired in 1948. Mr. Goodman, who held bachelor of philosophy and master of arts degrees from Bucknell University, had participated as an expert witness in various rate cases. Born February 19, 1883, in Loganton, Pa., he was a Member-for-Life.

Harry Curtis Hall (A '01, M '13), retired electrical engineer, of New Rochelle, N. Y., died June 20, 1949. Born in Glen Cove, Long Island, August 4, 1879, Mr. Hall graduated from the Brooklyn Polytechnic

Institute in 1902 with a degree in electrical engineering. Subsequently, he went to work for the New York Edison Company, and in 1905, he became identified with the General Electric Company, Schenectady, N. Y. After three years in the Testing Department, he was transferred to the company's Experimental Railway Department. Following one year in the Lighting Department, he moved to General Electric's New York, N. Y., office, becoming a sales engineer. Joining the Richmond Light and Railroad Company, Staten Island, N. Y., in 1914, he was designated Superintendent of Construction, American Public Service Company, Abilene, Tex., one year later. In 1916, he became associated with H. E. Mole, Consulting Engineer of New York, N. Y. Subsequently, he was identified with the Southwest Public Utilities Company and the Allis-Chalmers Manufacturing Company in New York. In more recent years, he engaged in the designing of boats, being at one time employed as Chief Design Engineer for Ratsey and Lapthorn, Inc., City Island, N. Y. Mr. Hall was a Member-for-Life.

Cecil Miguel Munoz (A '16), formerly President and Chairman of the Board of the electrical engineering firm of Harry Alexander, Inc., New York, N. Y., and Washington, D. C., died at his home in Pacific Palisades, Calif., on July 6, 1949. Born September 19, 1884, in Brooklyn, N. Y., he went to work for the Thompson-Starret Company in 1901. In 1907, he joined the Cleveland and Ryan organization. Remaining there three years, his next position was with Harry Alexander, Inc. He rejoined the Thompson-Starret firm in 1912. Two years later, he returned to Harry Alexander, Inc., and was identified with that firm for the duration of his working career. Before becoming President of the company, he had held the designation of General Manager and then that of Vice-President and General Manager. He was a Member-for-Life.

Eleazer Albert Vaughan (M '22), former Manager, Lompoc Light and Water Department, Lompoc, Calif., died July 10, 1949. He was born in Hull, Wis., on February 27, 1880. From 1898 to 1911, he held various positions in the electrical industry. In the latter year, he accepted the post of Superintendent with the Antigo (Wis.) Electric Company. He entered the automotive repair business in 1913 and continued in it until 1918. At that time, he was employed as General Superintendent for the Lompoc utility. Six years thereafter, he was appointed Manager.

MEMBERSHIP

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before October 25, 1949, or December 25, 1949, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Bergan, M. D., The Thomas & Betts Co., Elizabeth, N. J.
Butler, O. I., The University, Sheffield, England
Cowie, D. B., Carnegie Inst. of Washington, Washington, D. C.
Dawson, J. P., Public Utilities Comm., Woodstock, Ontario, Canada
Dolde, W. J., Public Service Co. of N. Mex., Albuquerque, N. Mex.
Dumont, G., The Stanstead Electricity Corp., Coaticook, Quebec, Canada
Fowler, R. W., Univ. of Cincinnati, Cincinnati, Ohio
Graves, J. A., Westinghouse Elec. Corp., Philadelphia, Pa.
Griffin, W. S., 53 Larkspur Terrace, Jesmond, Newcastle-on-Tyne, Northumberland, England
Guidry, J. E., Bureau of Reclamation, Washington, D. C.
Hanson, E. B., General Elec. Co., San Francisco, Calif.
Hillebrandt, B. F., Black & Veatch, Kansas City, Mo.
Ireland, E., City of Los Angeles, Los Angeles, Calif.
Jackson, G. F., George A. Fuller Co., Chicago, Ill.
Karrer, L. E., Puget Sound Power & Light Co., Seattle, Wash.
London, C., Westinghouse Elec. Corp., Baltimore, Md.
London, H. A., Westinghouse Elec. Corp., El Paso, Tex.
Maytham, W. J., Jr., Westinghouse Elec. Corp., Chicago, Ill.
McCall, A. E., McCall-Thomas Engg. Co., Inc., Orangeburg, S. C.
McKeen, J. E., Bechtel Corp., San Francisco, Calif.
Meltzer, L., Burndy Engg. Co., Bronx, N. Y.
Ritz, W. A., Bureau of Ships, Navy Dept., Washington, D. C.
Rupp, W., (re-election) P. O. Box 951, Seattle, Wash.
Sarrault, M. A., The Narragansett Elec. Co., Providence, R. I.
Schnoor, H. L., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Sciotti, F., The Narragansett Elec. Co., Providence, R. I.
Shetzalia, L. D., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Singh, H., Chakeri Aerodrome, Kanpur, India
Thompson, R. G., Metropolitan Life Insurance Co., New York, N. Y.
Vogelman, J. H., Watson Labs., Red Bank, N. J.
Weiss, R. A., Imperial Irrigation District, Imperial, Calif.
White, W. R., 204 Barker Bldg., Omaha, Nebr.
Wust, A., Societe d'Electricite de l'Escaut Antwerp, Belgium

33 to grade of Member

To Grade of Associate

United States, Canada, and Mexico

1. North Eastern

Arrison, R. A., Jr., 530 Beacon St., Boston, Mass.
Bonacker, E., 63 Willard Ave., Springfield, Mass.
Brule, J. D., 65 E. Genesee St., Auburn, N. Y.
Cardin, W. W., 39 South St., Foxboro, Mass.
Chadwick, M. M., General Elec. Co., Schenectady, N. Y.
Dick, C. W., General Elec. Co., Pittsfield, Mass.
Donovan, E. P., 207 Cottage Park Rd., Winthrop, Mass.
Folsom, K. E., (Student), Univ. of New Hampshire, Durham, N. H.
Funsett, D. H., General Elec. Co., Pittsfield, Mass.
Harper, W. R., Jr., 1729 Wampanoag Trail, Barrington, R. I.
Howland, P. H., General Elec. Co., Schenectady, N. Y.
Johnson, E. M., 517—5th Ave., Troy, N. Y.
Knecht, W. A., Haydon Mfg. Co., Torrington, Conn.
Libby, A. L., Lynn Gas & Elec. Co., Lynn, Mass.
Linsley, F. H., The Connecticut Light & Power Co., Waterbury, Conn.
McCuen, J. W., General Elec. Co., Schenectady, N. Y.
Mindt, F. E., Jr., 61 Swan St., Lawrence, Mass.
Muirhead, W., General Elec. Co., Schenectady, N. Y.
Olson, H. A., General Elec. Co., Schenectady, N. Y.
Penley, R. L., Hamilton Standard Propellers, E. Hartford, Conn.
Petty, P. C., General Elec. Co., Schenectady, N. Y.
Pike, D. C., 553 Circuit Rd., Portsmouth, N. H.
Romberg, R. E., 22 Waite Street, Hamden, Conn.
Single, H. C., 231 Roslindale Ave., Roslindale, Mass.
Stave, K. V., General Elec. Co., Schenectady, N. Y.
Walsh, J. L., 121 Lennon St., Providence, R. I.
Wetzell, D. F., 642 Belmont St., Brockton, Mass.
Whitney, E. G., 5 Ryder St., N. Dartmouth, Mass.
Wrubel, J. S., 5 Allison St., Middletown, Conn.

2. Middle Eastern

Alexander, W. E., Jr., R.C.A., Lancaster, Pa.
Behler, C. W., Atlantic City Elec. Co., Atlantic City, N. J.
Bender, P. A., Consolidated Gas & Elec. Co., of Baltimore, Baltimore, Md.
Biss, M. W., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Bjorklund, A., Ohio Edison Co., Springfield, Ohio
Bogart, R. B., Austin Co., Cleveland, Ohio
Bonini, B., General Elec. Co., Erie, Pa.
Braly, R. E., Consolidated Gas, Elec. Lt. & Power Co. of Baltimore, Baltimore, Md.
Byrd, R., 5609 University Drive, Hyattsville, Md.
Carlisle, L. H., 2140 7th St., Cuyahoga Falls, Ohio
Carter, J. F., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Castle, J. B., Aluminum Co. of America, New Kensington, Pa.
Churbock, J. P., P. O. Box 18, Loyalhanna, Pa.
Coon, G. M., The Clark Controller Co., Akron, Ohio
Cronin, E. J., Jr., Philadelphia Elec. Co., Norristown, Pa.
Doberdruk, A., The Austin Co., Cleveland, Ohio
Egli, G. E., Air Materiel Command, Dayton, Ohio
Ellison, R. A., Bell Tel. Co. of Pa., Pittsburgh, Pa.
Engler, A. R., Philco Corp., Sandusky, Ohio
Evans, D. C., Northern Pennsylvania Power Co., Mansfield, Pa.
Gillespie, R. A., Bell Tel. Co., Pittsburgh, Pa.
Gleisser, N. B., West Penn. Power Co., Pittsburgh, Pa.
Greene, S. G., Philadelphia Signal Corps Depot, Philadelphia, Pa.
Hand, E. J. (re-election), Dept. of Commerce, Washington, D. C.
Hermeling, G. C., Jr., R.C.A. Victor Div. Camden, N. J.
Hicks, W. W., General Elec. Co., Cleveland, Ohio
Hutchison, T. C., Haller, Raymond & Brown, Inc., State College, Pa.
Jackson, P. W., I.B.M., Washington, D. C.
Kinney, R. F., Allis-Chalmers, Norwood, Ohio
Koepfinger, J. L., Duquesne Light Co., Pittsburgh, Pa.
McNeal, R. H., Cleveland Elec. Illuminating Co., Elyria, Ohio
Mesmeringer, J. C., Jr., Bendix Radio, Towson, Md.
Minnich, O. R., Appalachian Elec. Power Co., Huntington, W. Va.
Molinski, A. E., (re-election), Bethlehem Collieries Corp., Johnstown, Pa.
Neubert, H. A., Jr., Elec. Service Mfg. Co., Philadelphia, Pa.
O'Mara, J. F., General Elec. Co., Philadelphia, Pa.
Patterson, K. M., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Paul, E. A., The Scranton Elec. Co., Scranton, Pa.
Roediger, F. E., The Ordnance School, Aberdeen Proving Ground, Md.
Scarcelli, J. A., U. S. Naval Air Development Station, Johnsville, Pa.
Schaefer, G. J., Aluminum Co. of America, Cleveland, Ohio
Schmidt, W. O., Baldwin Locomotive Works, Eddystone, Pa.
Schmunk, J. M., R.C.A., Camden, N. J.
Sesler, L. H., Jr., Stope 811/4 Lake Rd., Lorain, Ohio
Shafer, P. E., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Smith, F. J., Philadelphia, Elec. Co., Norristown, Pa.
Strongin, I., Signal Corps Engg. Labs., Philadelphia, Pa.
Walker, E. F., James Paul Warner, Electrical Engineer, Pittsburgh, Pa.
Wisniewski, T. F., 326 Lighthouse St., Erie, Pa.

3. New York City

Alster, D. I., 1520 Crotona Park East, Bronx, N. Y.
Bisbee, J. M. (re-election), Consolidated Edison of N. Y., Inc., New York, N. Y.
Catapano, R. L., 189 Essex St., Brooklyn, N. Y.
Coster, G. F., Westchester Lighting Co., Mt. Vernon, N. Y.
Epstein, M., 5411 Fort Hamilton P'kway., Brooklyn, N. Y.
Fiske, J. W., R.C.A., Harrison, N. J.
Gellhaus, K. M., McGraw-Hill Publishing Co., New York, N. Y.
Goldberg, E., 2157 Pacific St., Brooklyn, N. Y.
Gonzales, R. F., 693 Cauldwell Ave., Bronx, N. Y.
Gould, L. M., Polytech. Inst. of Brooklyn, Brooklyn, N. Y.
Hartnett, E. J., 210 Charles Ave., Staten Island, N. Y.
Hollander, J. M., 140 W. 86th St., New York, N. Y.
Hollander, S. E., Long Island Lighting Co., Mineola, N. Y.
Izzo, R., Board of Education, New York, N. Y.
Janos, G. L., Arma Corp., Brooklyn, N. Y.
Klein, S., 2474 Grand Ave., New York, N. Y.
Levy, B., Colonial Elec. Products, Inc., E. Paterson, N. J.
Meyers, G., Hittner Elec. Co., New York, N. Y.
Nafis, R. A., Grumman Aircraft Engg. Corp., Bethpage L. I., N. Y.
Roth, H., A.M.R. Radio Co., New York, N. Y.
Ryan, M. J., 334 E. 205th St., New York, N. Y.
Schwanhauser, J. F., Public Service Elec. & Gas Co., Newark, N. J.
Singer, R. J., 150 Riverside Drive, New York, N. Y.
Siskind, F. Ward Leonard Elec. Co., Mt. Vernon, N. Y.
Tall, M. M., 740 Empire Blvd., Brooklyn, N. Y.
Teets, W. M., 768 Carleton Rd., Westfield, N. J.

4. Southern

Arnold, E. H., Jr., Delta Electrical School, Inc., New Orleans, La.
Bednarz, W., General Cable Corp., New Orleans, La.
Bishop, B. C., Greenwood County Elec. Power Comm., Chappells, S. C.
Blackburn, G. S., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Brooks, J. C., 21 Enterprise St., Raleigh, N. C.
Carter, W. J., Watauga Dam, Elizabethton, Tenn.
Cole, W. H., Florida Power & Light Co., Miami, Fla.
Comstock, A. L., Hastings Instrument Co., Inc., Hampton, Va.
Costello, L. F., BuYards & Docks, Arlington, Va.
Daset, C. S., Jr., I.B.M., New Orleans, La.
Farley, J. G., Jr., Alabama Power Co., Birmingham, Ala.
Fisher, C. F., Du Pont de Nemours, Martinsville, Va.
Flach, G. W., Delta Elec. School, New Orleans, La.
Forsyth, H. W., 128 Park Street, Pikeville, Ky.
Guice, W. R., Southwestern Gas & Elec. Co., Shreveport, La.
Holloman, J. B., Aluminum Co. of America, Atlanta, Ga.
Jennings, Z. A., 1430 Redgate Ave., Norfolk, Va.
Lochridge, R. W., (Student), Alabama Polytech. Inst. Auburn, Ala.

McGee, D. H., Texas Gas Transmission Corp., Memphis, Tenn.
Melchers, J. T., Jr., 123 Jersey Lane, Clemson, S. C.
Miner, H. R., Tennessee Polytechnic Inst., Cookeville, Tenn.
Passera, A. L., Natl. Advisory Comm. on Aeronautics, Hampton, Va.
Skinner, R. N., Box 241, Vero Beach, Fla.
Vanderford, W. E., Alabama Power Co., Birmingham, Ala.
Wood, P. E., Jr., I.B.M. Corp., Norfolk, Va.

5. Great Lakes

Battocletti, J. H., Motorola, Inc., Chicago, Ill.
Bentheimer, W. P., Rock County Elec. Co-op Assoc., Janesville, Wis.
Berg, S. L., Carnegie Illinois Steel Corp., Gary, Ind.
Bowen, J. W., Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Brown, R. G., Westinghouse Elec. Corp., Chicago, Ill.
Buchberger, R. L., Box 114, Marathon, Wis.
Butler, D. R., R. F. Scherer Corp., Detroit, Mich.
Cassidy, P. R., Sargent & Lundy, Chicago, Ill.
Christensen, C. M., Micro Switch Div., Freeport, Ill.
Clymer, H. F., (Student), Purdue Univ., W. Lafayette, Ind.
Constant, J. N. (Student), Univ. of Michigan, Ann Arbor, Mich.
Corbin, L. L., Aluminum Co. of America, Davenport, Iowa
Cox, C. W., Rose Polytechnic Inst., Terre Haute, Ind.
Crocker, R. E., General Elec. Co., Brighton, Mich.
Dailey, W., 1158 S. Lombard Ave., Oak Park, Ill.
Deschner, F. S., Westinghouse Elec. Corp., Chicago, Ill.
DiMarco, T. J., 1235 N. Van Buren St., Milwaukee, Wis.
Dodds, R. P., Westinghouse Elec. Corp., Chicago, Ill.
Dudley, T. V., 606 Lake Ave., Wilmette, Ill.
Edwards, A., Jr., Northwestern Tech. Inst., Evanston, Ill.
Eigner, R. G., 3815 N. Frederick Ave., Milwaukee, Wis.
Engen, J. K., Univ. of Illinois, Urbana, Ill.
Ethington, P. J., 517 Welch Ave., Ames, Iowa
Fitzgerald, A. T., 8 S. Electrical Meters, Chicago, Ill.
Furlong, J. W., Univ. of Detroit, Detroit, Mich.
Gavin, W. R., 2115 So. 10th St., Milwaukee, Wis.
Gilchrist, F. W. (re-election) Cutler-Hammer Inc., Indianapolis, Ind.
Green, R. E., Morton Gregory Corp., Detroit, Mich.
Hafvenstein, J. D., Minneapolis Honeywell Regulator Co., Minneapolis, Minn.
Hanner, M. E., Commonwealth & Southern, Jackson, Mich.
Hanson, W. A., Lee Engineering Co., Milwaukee, Wis.
Haraburda, J. L., Jr., Kelso-Burnett Elec. Co., Chicago, Ill.
Hayne, L. F., Allis-Chalmers Mfg. Co., West Allis, Wis.
Hodell, J. G., Western Elec. Co., Inc., Chicago, Ill.
Hollingsworth, T., Westinghouse Elec. Corp., Chicago, Ill.
Hubbard, W. E., Stephenson, Mich.
James, H. A., 7415 No. Paulina St., Chicago, Ill.
Johnson, R. E., Westinghouse Elec. Corp., Chicago, Ill.
Jones, E. L., 369 Louise, Highland Park, Mich.
Karkenki, J., Jr., 110 S. Kensington, Laurium, Mich.
Kenney, J. C., (re-election), Westinghouse Elec. Corp., Chicago, Ill.
Koniar, J. S., 4554 So. Whitnall Ave., Cudahy, Wis.
Kunts, W., Route 1, Ridgeway, Iowa
La Duke, J. A., c/o John Whipple, Rt. #1, 458 Abbott Rd., Midland, Mich.
Langenkamp, Q. W., Marquette Univ., Milwaukee, Wis.
Lins, C. A., Westinghouse Elec. Corp., Chicago, Ill.
Lund, T. J., Minnkota Power Inc., Grand Forks, N. Dak.
Marquart, R. L., Indiana Bell Tel. Co., South Bend, Ind.
Marsolek, E. M., 728 South 3rd St., Milwaukee, Wis.
Martin, D. B., (Student), Univ. of Minn., Minneapolis, Minn.
Masten, R. J., 46 Bosart Ave., Indianapolis, Ind.
McCarthy, H. J., American Television Inst., Chicago, Ill.
McCarthy, R. B., Line Material Co., S. Milwaukee, Wis.
Neuman, W. E., Audio Development Co., Minneapolis, Minn.
O'Brien, J. A., Radio Station *WDGY*, Oxboro, Minn.
Perina, E. J., 2619 So. Pulaski Rd., Chicago, Ill.
Petzold, C. D., Wisconsin Gas & Elec. Co., Waukesha, Wis.
Pottenger, J. L., Westinghouse Elec. Corp., Chicago, Ill.
Robinson, J. L., (Student), Milwaukee School of Engineering, Milwaukee, Wis.
Rock, G. L., Allen Bradley Co., Milwaukee, Wis.
Ross, D. J., 111 Johnson St., Michigan City, Ind.
Sandell, D. H., Montana-Dakota Utilities Co., Mobridge, S. Dak.
Saxer, H. A., A. C. Skon Co., Chicago, Ill.
Schmidt, D. M., R. R. 4., Mt. Vernon, Ind.
Schultz, C. J., Consumers Power Co., Jackson, Mich.
Skala, R. E., Sargent & Lundy, Chicago, Ill.
Skenandore, J. G., 1032 N. 17th Street, Milwaukee, Wis.
Skiles, H. L., 541 Toepfer Ave., Madison, Wis.
Solomon, L. P., Sr., Dept. of Water Supply, Detroit, Mich.
Stampfl, V. F., Allen Bradley Co., Milwaukee, Wis.
Stowitts, H. T., Jr., Michigan Bell Tel. Co., Detroit, Mich.
Striebel, D. R., Western Elec. Co., Chicago, Ill.
Trotter, J. D., Westinghouse Elec. Corp., Chicago, Ill.
Vander Haas, H. H., (Student) Pierre Indian School, Pierre, S. Dak.
Welch, G. L., Westinghouse Elec. Co., Chicago, Ill.
White, F., Westinghouse Elec. Corp., Chicago, Ill.
Zanakas, A. S., (Student), Milwaukee School of Engg., Milwaukee, Wis.
Zimmerman, R. S., Dittmore & Freimuth Engg. Co., Milwaukee, Wis.

6. North Central

Case, R. B., R. W. Beck & Assocs., Columbus, Nebr.
Cleaveland, G. W., U. S. Bureau of Reclamation, Denver, Colo.
Cochran, J., Consumers Public Power District, Lincoln, Nebr.
Creager, C. W., Mts. State Tel. & Tel. Co., Laramie, Wyo.
Dillinger, D. F., Denver Federal Center, Denver, Colo.
Eckblade, C. J., Bellevue Power Sta., Bellevue, Nebr.
Frary, R. S., Q-341 Vetsville, Boulder, Colo.
Jacobson, R. S., U. S. Bureau of Reclamation, Denver, Colo.
Kepka, W., 2715 S. 16th St., Lincoln, Nebr.
Kisler, M. J., Bellevue Power Station, Bellevue, Nebr.
Livingston, H. A., U. S. Rubber Co., Omaha, Nebr.
Phillips, A. H., General Elec. X-Ray Corp., Denver, Colo.
Radnor, R. R., 1521—10th Ave., Greeley, Colo.
Smith, R. E., Box 1370, Rapid City, S. Dak.

7. South West

Abadie, V. H., Jr., Arthur L. Nelson Engrs., Blanco, Tex.
Almond, T. D., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Almquist, C. A., Cessna Aircraft, Wichita, Kans.
Barbee, H., Box 23, Quinlan, Tex.
Barron, R., G. E. Jones Elec. Co., Inc., Amarillo, Tex.
Bradley, W. R., Southwestern Public Service Co., Amarillo, Tex.
Carr, B. J., Consolidated Vultee Corp., Ft. Worth, Tex.
Cooper, E. K., New Mexico Broadcasting Co., Albuquerque, N. Mex.
Cousins, C. J., State Highway Comm. of Kansas, Oil Hill, Kans.
Decker, J. P., Arkansas Power & Light Co., Pine Bluff, Ark.
Easley, T. O., 118 South Cornell, Albuquerque, N. Mex.
Estrada, G. F., 3ra. Alconedo #62., Mixcoac, Mexico, Federal District, Mexico
Fleck, F. J., (Student), Southern Methodist Univ., Dallas, Tex.
Gans, G. D., General Elec. Co., Dallas, Tex.
Garrett, H. M., Jr., Texas Elec. Service Co., Big Spring, Tex.
Gray, J. P., Jr., Southwestern Public Service Co., Borger, Tex.
Harshbarger, F. V., 1205 W. 16th St., Topeka, Kans.
Harvey, C. R., Public Service Co. of Okla., Lawton, Okla.
Jackson, H. S., 419 N. 19th, Fort Smith, Ark.
Jordan, J. T., Roosevelt Co. Elec. Co., Portales, N. Mex.
Kern, K. J., Finaly Engg. College, Kansas City, Mo.
Logan, J. M., Black & Veatch, Kansas City, Mo.
Mazzone, J. P., 718 N. Piedras, El Paso, Tex.
Matzen, W. T., A & M College, College Station, Tex.
Norman, T. J., Jr., 1812 N. Congress, Austin, Tex.
Posey, O. S., Union Elec. Co. of Missouri, St. Louis, Mo.
Price, G. W., Sverdrup & Parcel, St. Louis, Mo.
Price, W. E., Jr., Southwestern Public Service Co., Amarillo, Tex.
Quade, R. C., 6655 Garner Ave., St. Louis, Mo.
Ruff, R. E., Bell Tel. Co., Wichita, Kans.
Schafie, F. G., H. N. Roberts & Assoc., Lubbock, Tex.
Thompson, R. H., Emerson Elec. Mfg. Co., St. Louis, Mo.
Walker, J. B., Jr., Williamson Sales Co., Amarillo, Tex.
Williams, A. F., Jr., The Texas Pipe Line Co., Houston, Tex.
Woods, J. L., Consolidated Vultee Aircraft Corp., Convair, Ft. Worth, Tex.
Woolworth, D., Board of Public Utilities, Kansas City, Kans.

8. Pacific

Bailor, J. H., General Elec. Co., Reno, Nev.
Banks, D. C., General Petroleum Corp., Torrance Refinery, Calif.
Blum, F. N., General Elec. Co., San Francisco, Calif.
Bohannon, H., Sulphur Springs Valley Elec. Coop., Willcox, Ariz.
Booth, J. E., Jr., Pacific Gas & Elec. Co., Hayward, Calif.
Brenton, R. F., Kennecott Co. Corp., McGill, Nev.
Bryner, D. B., Arizona Edison Co., Phoenix, Ariz.
Calhan, W. L., Pacific Gas & Elec. Co., Healdsburg, Calif.
Chambers, H. V., Tucson Gas, Elec. Light & Power Co., Tucson, Ariz.
Chandler, W., Western Air Lines, Los Angeles, Calif.
Coordell, E. L., Univ. of California, Berkeley, Calif.
Danielson, E., Jr., The Okonite Co., San Francisco, Calif.
Ellsworth, R. L., 2268 Cedar St., Berkeley, Calif.
Flowers, W. A., Pacific Gas & Elec. Co., Petaluma, Calif.
Forney, R. G., 1415 Bank Ste., S. Pasadena, Calif.
Gawf, J. L., Bechtel Corp., San Francisco, Calif.
Goodman, K., 149 West Avenue 30, Los Angeles, Calif.
Hart, D. F., Arizona Edison Co., Inc., Phoenix, Ariz.
Jack, M. G., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Jenkins, C. J., Douglas Aircraft Co., Inc., Santa Monica, Calif.
Kappelman, R. V., City of Tucson Planning Bd., Tucson, Ariz.
Kimball, J. T., Central Arizona Light & Power Co., Phoenix, Ariz.
Kostka, A. O., 301 S. Kenmore Ave., Los Angeles, Calif.
Lasater, J. D., Mohave Elec. Cooperative, Kingman, Ariz.
McClanahan, R. H., Bechtel Corp., San Francisco, Calif.
Menke, E. M., 717 So. Center, Reno, Nev.
Moberly, R. G., 13511 So. Crenshaw Blvd., Hawthorne, Calif.
O'Brien, J. S., 2242 N. 9th St., Phoenix, Ariz.
Monahan, W. F., 1023 Cerritos Ave., Long Beach, Calif.
Northoff, N. F., Jr., 410 Vernon St., Oakland, Calif.
Rhodes, N. E., Pacific Gas & Elec. Co., San Francisco, Calif.
Rogers, B. D., Salt River Valley Water Users Assn., Phoenix, Ariz.
Rothermel, E. H., General Elec. Co., San Francisco, Calif.
Sims, M. H., Bechtel Corp., San Francisco, Calif.
Stivers, W. C., Bechtel Corp., San Francisco, Calif.
Thornton, E. J., 17304 Wilkie Ave., Torrance, Calif.
Thureson, S. H., Bechtel Corp., San Francisco, Calif.
Wadleigh, J. E., Kaiser Co., Inc., Fontana, Calif.
White, J. T., Bechtel Corp., San Francisco, Calif.
Yost, D. A., Bechtel Corp., San Francisco, Calif.

9. North West

Arnold, E. B., Boeing Airplane Co., Seattle, Wash.
Barnes, R. O., Bonneville Power Admin., Vancouver, Wash.
Davis, J. A., General Elec. Co., Salt Lake City, Utah
Hartman, E. G., Boeing Airplane Co., Seattle, Wash.
Hayes, W. E., Boeing Aircraft Co., Seattle, Wash.
Haynes, J. W., Grangeville, Idaho
Horn, R. W., U.S.N.A.S., Seattle, Wash.
Roedel, J., Boeing Aircraft Co., Seattle, Wash.
Vickerman, E. T., Jr., Washington Water Power Co., Spokane, Wash.

10. Canada

Bishop, R. M., Toronto Hydro Elec. System, Toronto, Ontario, Canada
Brereton, R. L., Canada Wire & Cable Co. Ltd., Toronto, Ontario, Canada
Brophy, C. P., Bell Tel. Co., Montreal, Quebec, Canada
Brotherton, L. W., Canadian Westinghouse Co., Hamilton, Ontario, Canada
Corbett, F. M., Canadian General Elec. Co., Toronto, Ontario, Canada
Crompton, H., BEPCO Canada Ltd., Toronto, Ontario, Canada
Desjardins, G. M., Northern Elec. Co., Toronto, Ontario, Canada
Edwards, F. H., Canadian Westinghouse Co., Hamilton, Ontario, Canada
Flom, M., Elec. Tamper & Equipt. Co., Montreal, Quebec, Canada
Garnett, J. B., Canada Wire & Cable Co. Ltd., Toronto, Ontario, Canada
Grant, D. S., Canada Wire & Cable Co. Ltd., Leaside, Ontario, Canada
Gray, W. M., Northern Elec. Co. Ltd., Vancouver, British Columbia, Canada
Henderson, J. G. C., Canada Wire & Cable Co. Ltd., Toronto, Ontario, Canada
Hinton, F. R., Canadian General Elec. Co., Toronto, Ontario, Canada
Hornby, F. G., Quebec North Shore Paper Co., Baie Comeau, Quebec, Canada
Hudson, J. J., Canadian General Elec. Co., Peterborough, Ontario, Canada
Kanwischer, W., 380 E. 49th Avenue, Vancouver, British Columbia, Canada
Kennedy, W. W., Northern Elec. Co. Ltd., Montreal, Quebec, Canada
Kuhn, B. G., R.C.A.F., Dorval Airport, Quebec, Canada
LeBlanc, F. J., Sangamo Co. Ltd., Montreal, Quebec, Canada
Leonidas, T. A., Provincial Mental Hospital, Essondale, British Columbia, Canada
Macdonald, C. H., Ontario Hydro-Elec. Power Comm., Toronto, Ontario, Canada
Mitchell, G. W., Canadian Westinghouse, Hamilton, Ontario, Canada
Mulqueen, J. T. D., Intl. General Elec. Co., Peterborough, Ontario, Canada
Murray, D. M., National Research Council, Ottawa, Ontario, Canada
Neame, H. W., Hydro-Elec. Power Comm. of Ont., Toronto, Ontario, Canada
Pant, R. C., The Hydro-Elec. Power Comm. of Ontario, Toronto, Ontario, Canada
Parkhill, D. F., Canadian Comstock Frequency Conversion Div., St. Catharines, Ontario, Canada
Scott, E. M., Winnipeg Elec. Co., Winnipeg, Manitoba, Canada
Short, R. C., Packard Elec. Co., Ltd., St. Catharines, Ontario, Canada
Soutar, H. R., Windsor Utilities Comm., Windsor, Ontario, Canada
Stachon, J. A., Royal Canadian Navy, HMCS Stadacona, Halifax, Nova Scotia, Canada
Venutti, D. L. B., Hydro-Elec. Power Comm., Toronto, Ontario, Canada

Elsewhere

Ayyar, C. D., Metropolitan Vickers Elec. Co. Ltd., Trafford Park, Manchester, England
Edwards, C. V., McKenzie City, Demerara River, British Guiana, South America
Emery, R. E., LaLuz Mines Ltd., Suina, Via Managua, Nicaragua, Central America
Ghosh, S. K., English Elec. Co., Stafford, England
Mallikarjunan, T., The Chittoor Elec. Supply Corp., Ltd., Chittoor District (S. India)
Mital, V. C., Hydro-Elec. Dept., Roorkee, (U. P.) India
Modak, R. D., Bombay Suburban Elec. Supply Co., Bombay, India
Parekh, S. L., c/o Dr. L. H. Parekh, Pilaji Ganj, Mehsana, North Gujerat, India
Slootweg, A. M. R., The Yorkshire Switchgear Engg. Co. Ltd., Meanwood, Leeds, England

Total to grade of Associate
United States, Canada, and Mexico, 319
Elsewhere, 9

Scopes of AIEE Technical Subcommittees

The following sections list the names and scopes of the subcommittees of the various AIEE technical committees. These subcommittees are organized under their respective main committees, and in turn, under the following groups: Communication; General Applications; Industry; Power; and Science and Electronics. A list of the scopes of the main AIEE technical committees appeared in September (*EE, Sep '49, pp 808–11*).

Communication Group

AURAL BROADCASTING SUBCOMMITTEES

1. Subcommittee on Transmission Systems

2. Subcommittee on Receivers

COMMUNICATION SWITCHING SYSTEMS SUBCOMMITTEES

No subcommittees have been appointed as yet.

RADIO COMMUNICATION SYSTEMS SUBCOMMITTEES

1. Subcommittee on Mobile Radio

2. Subcommittee on Point-to-Point Radio

SPECIAL COMMUNICATION APPLICATIONS SUBCOMMITTEES

1. Subcommittee on Electro-Acoustics

2. Subcommittee on Railroad Communications

3. Subcommittee on Special Activities

TELEGRAPH SYSTEMS SUBCOMMITTEE

1. Subcommittee on Facsimile

TELEVISION BROADCASTING SYSTEMS SUBCOMMITTEES

1. Subcommittee on Transmission Systems

Scope—Comprises activities related to television broadcasting transmission systems including transmitters, studio and mobile pickup equipment, studio-transmitter links, antennas, and propagation.

2. Subcommittee on Receivers

Scope—Comprises activities related to television broadcast receivers, antennas and receiving systems.

WIRE COMMUNICATION SYSTEMS SUBCOMMITTEE

1. Subcommittee on Power Line Carrier

General Applications Group

AIR TRANSPORTATION SUBCOMMITTEES

1. Aircraft Electrical Control Protective Devices and Cable Subcommittee

Scope—Formation of test codes and operating standards for aircraft electric control, protective devices, and cable. The subcommittee is engaged presently in the preparation of a test code for aircraft circuit interrupting devices and a test code for aircraft d-c generator voltage regulators is being prepared by a working group of the subcommittee.

2. Aircraft Electrical Rotating Machinery Subcommittee

Scope—This subcommittee was organized in 1944 for the purpose of preparing standard test codes for aircraft electric rotating machinery. As a result, AIEE 800, "Proposed Test Code for D-C Aircraft Machines," was published in March 1947 for one year trial use. The subcommittee now is preparing "Rating Standards for Engine-Driven Generators."

3. Aircraft System Subcommittee

Scope—The purpose of this subcommittee is to formulate a report on the basic and accepted considerations involved in the application practice of aircraft electric systems. This report shall contain information of the following character: An explanation of fundamental electrical problems, outlines of systematic procedures for analysis and computation of aircraft electric system performance, and formulation of general application practices which will assure correct co-ordination of equipment.

4. Subcommittee on Basic Principles of Altitude Rating of Electric Apparatus

Scope—This subcommittee will prepare no test codes nor standards for specific apparatus; rather, it will prepare a report indicating the basic principles of altitude rating of electric apparatus. Such a report will be useful in the preparation of test codes and standards and in the design and testing of aircraft equipment. The first phase of the project will be from sea level to 50,000 feet altitude.

DOMESTIC AND COMMERCIAL APPLICATIONS SUBCOMMITTEES

No subcommittees have been appointed.

LAND TRANSPORTATION SUBCOMMITTEES

1. Heavy Traction Electrification Data Subcommittee

Scope—To collect and tabulate data covering power supply, conversion, distribution systems, and motive power of electrified railroads in the United States and foreign countries.

Projects—(1-1). Catenary overhead systems.
(1-2). Third rail systems.
(1-3). Electric locomotives.
(1-4). Substations.
(1-5). Power supply.

2. Heavy Traction Papers and Plans Subcommittee

Scope—To secure papers and discussion for the various AIEE meetings, covering matters of current interest in the field relating to railroad electrification, diesel-electric locomotives, and all other applications of electricity to railroad rolling stock such as lighting and air conditioning passenger cars. This is accomplished by correspondence and personal contact with the leading manufacturers of equipment, and the engineering personnel of the major electrified railroads and consulting engineering firms engaged in such projects.

3. Light Traction Papers and Plans Subcommittee

Scope—To secure papers and discussion for the various AIEE meetings, covering matters of current interest in the field relating to local transit, that is, subway, streetcar, and trolley coach systems, and applications of electric propulsion equipment to internally powered local transit vehicles.

4. Subcommittee on Revision of AIEE Standard 16 (Electric Railway Control Apparatus) ASA C48

Scope—To revise AIEE Standard 16 ("Electric Railway Control Apparatus") for the purpose of recognizing new processes, correction of errors, and inclusions of certain new functions and devices. These Standards last were revised in 1933. The subcommittee reported at the Montreal meeting, June 1947, and is expecting to present a final report soon.

MARINE TRANSPORTATION

1. Subcommittee on Power Generation

Scope—This committee to have cognizance of Sections 3, 5, 12, 15, 51, 52, 101 (except 101.33 and 101.35) of the AIEE Standards 45 dated December 1948. This to include d-c and a-c generator classification, also converters, balancers, and so forth, and a description of each type. The scope of this committee also covers classes of insulation material and description thereof, likewise d-c and a-c equipment and installation.

2. Subcommittee on Power Application

Scope—This committee to have cognizance over Sections 4, 6, 7, 8, 9, 10, 24, 25, 26, 28, 45, 60, 61, 63, 78, 102.01 to 102.17 inclusive, 102.21, and 103. This to include d-c and a-c motor classification and application and a description of each type. The scope of this committee also covers d-c electrically operated watertight fire door equipment, d-c and a-c control and application, d-c and a-c ship tests, a-c electric propulsion installations, also trials, operation, and maintenance.

3. Subcommittee on Wires and Cables

Scope—This committee to have cognizance over Sections 18, 19, 44.07, 54, 55, 101.33, and 101.35 of the AIEE Standards 45 dated December 1948. This to include a-c and d-c wires and cables covering construction, current carrying capacity, tests, and so forth, as applied to shipboard use.

4. Subcommittee on Switchboards and Controls

Scope—This committee to have cognizance over Sections 11, 17, 27, 29, 30, 31, 53, 62, 64, and 65 of the AIEE Standards 45 dated December 1948. This to include control apparatus and switchgear, both a-c and d-c defining each type of control and specifying construction of controls and switchboards, also application.

5. Subcommittee on Distribution

Scope—This committee to have cognizance over Sections 13, 14, 20, 21.01 to 21.69 inclusive, 21.81, 22, 23.23, 33.01 to 33.11 inclusive, 36, 44.01 to 44.05 (*a*) inclusive, 56, 57, 58, 67, 70 and 102.19. This to include distribution circuits for light and power, both a-c and d-c, as applied to shipboard; also a-c and d-c lighting equipment.

6. Subcommittee on Fittings and Appliances

Scope—This committee to have cognizance over Sections 16, 23 (except 23.23), 32, 33.13 to 33.33 inclusive, 34, 44.05 (*b*) to 44.09 inclusive, 59, 66, 67, and 68. This to include storage batteries covering installation

type, and location; also to include fittings and appliances for lighting and power as applied to shipboard.

7. Subcommittee on Communications and Alarms

Scope—This committee to have cognizance over Sections 21.71 to 21.79 inclusive, 37, 38, 71, and 72. This to include interior communication circuits and distribution, d-c and a-c, signal and communication system, including appliances.

8. Subcommittee on Navigation Equipment

Scope—This committee to have cognizance over Sections 35, 39, 40, 41, 42, 43, 44.11, 69, 73, 74, 75, 76, and 77. This to include d-c and a-c searchlights, d-c and a-c gyro compass and gyro pilot equipment, installation, wiring, power lines; d-c radio communication equipment, d-c and a-c radio direction finder equipment, d-c and a-c echo depth sounding equipment.

9. Subcommittee on Publicity, Personnel, History

Scope—The duty of this subcommittee is to publicize the Marine Committee and submit to the Secretary such items as are of interest to the Institute. This subcommittee is also required to keep a record of the personnel of the committee and recommend additions or changes of personnel to the committee. The subcommittee is also charged with the duty of keeping a history of the main committee.

10. Subcommittee on Editing

Scope—The duty of this subcommittee is to edit all motions passed at main committee meetings preparatory for revisions of the AIEE Recommended Practice for Electrical Installations on Shipboard number 45 and to make final check before the revisions are ready for the printer.

PRODUCTION AND APPLICATION OF LIGHT SUBCOMMITTEES

1. Ultraviolet Radiations Subcommittee

Scope—The initial scope will be to sponsor the preparation of a report on modern ultraviolet sources. The group also would serve as a clearing house for all information relating to its specific field, and will help in planning convention papers and securing speakers on this subject.

2. Nomenclature of Electronic Lamps Subcommittee

Scope—This subcommittee was formed for the purpose of co-operating with the subcommittee on electronic standards of the Committee on Electronics in the preparation of a system of definitions of electronic devices used as light sources. In this connection, light sources is taken as including sources of infrared, visible, and ultraviolet radiations.

3. Infrared Radiation Subcommittee

Scope—This subcommittee was organized to investigate electrical sources of infrared radiation and their application in co-operation with the other two AIEE infrared subcommittees: Radiant Heating Subcommittee under the Electric Heating Committee; Infrared Applications Subcommittee under the Electronics Committee.

The subcommittee is investigating electrical infrared sources and the techniques and instrumentation for the measurement of their radiant energy, with the purpose of submitting a suggested practical method for obtaining and presenting adequate data on infrared sources.

The subcommittee plans an investigation of the effect of various materials on infrared radiation with the hope of collecting adequate fundamental data for the practical determination of the desirability of using infrared radiation for various kinds of processes.

The subcommittee will encourage the use of electrical infrared radiation for those processes for which it is suitable by the collection and dissemination of available data, as well as the encouragement of new research.

Industry Group

CHEMICAL, ELECTROCHEMICAL, AND ELECTROTHERMAL APPLICATIONS SUBCOMMITTEES

1. Arc Furnaces and Electrothermal Processes Subcommittee

Scope—Study of the application of electrical apparatus in arc furnaces and electrothermal processes to formulate the principles of good engineering practice in these fields. This committee is also studying arc furnace designs, the effects of voltage surges in arc furnace circuits and power supply, and voltage regulation problems in arc furnaces and electrothermal processes.

2. Cathodic Protection Subcommittee

Scope—To develop the electrical engineering aspects of the application of cathodic protection. To promote a general understanding of those factors, under the control of designing and operating engineers, that contribute to corrosion and to its mitigation.

3. Electrolytic Processes Subcommittee

Scope—Treatment of all matters relative to electrolytic processes such as electrodeposition, electrolytic refining, electrolytic reduction, alkali chloride electrolysis, aqueous electrolytic processes. Such subjects as theory, technique, efficiency, plant, electrolytic cells, application of power conversion equipment, specialized equipment, and operating hazards are within the scope of this subcommittee.

4. Petroleum Refining and Production Subcommittee

Scope—Study of the application of electric apparatus to petroleum, natural gas, artificial gas, production, refining, and transportation to establish sound engineering practices in these fields.

5. Storage Batteries Subcommittee

Scope—This subcommittee has as its function the fostering of technical papers and the establishment of AIEE Standards, where needed, on all phases of storage battery design and engineering.

6. Chemical Industries Subcommittee

Scope—Study of the application of electric apparatus to the chemical industries to establish sound engineering practices in these fields. Particular attention is being given to the application of circuit breakers and control in the hazardous atmospheres which may be encountered.

ELECTRIC HEATING SUBCOMMITTEES

1. Subcommittee on Induction and Dielectric Heating

Scope—Study of the problem of interference from electronic heating equipment (with the advance of the Induction and Dielectric Heating Subcommittee, the Federal Communications Commission has formulated regulations, regarding the allowable limit of radiation from electronic heating equipment). Formulation of the principles of good engineering practice to deal with intolerable interference. Development of an AIEE Standard for electronic heating equipment including definitions of electronic heating terms.

2. Subcommittee on Radiant Heating

Scope—Standardization of industrial radiation heating in all of its phases. The advantages and limitations of infrared heating will be emphasized for the benefit of the engineering profession. It will cover the construction, optics, thermodynamics, and safety considerations associated with all high-temperature sources, correlation with other forms of electric heating, but not to include space heating.

3. Subcommittee on Radiation Measurements Above 200 Megacycles

Scope—All methods of measuring radiation up to and above 200 megacycles are being studied. Actual experimental work in various laboratories is being undertaken to develop methods of measurement in the frequency ranges where a satisfactory method does not now exist and to improve methods in those ranges where some work has been done to date.

4. Subcommittee on Resistance Heating and Electric Furnaces

Scope—To study and promulgate information on the use of resistance heating and electric furnaces in industry including such standardization as may be necessary.

ELECTRIC WELDING SUBCOMMITTEE

1. Power Supply for Resistance Welding Machines Subcommittee

Scope—Provision of basic information relating to power requirements and the effect of resistance welding loads from the standpoint of both users and utilities.

Outline economic considerations in the purchase and utilization as well as provision of power for welding including power factor correction, combined power and welding facilities.

Set up desirable practices and methods of procedure to be used in the selection of adequate power facilities for resistance welding.

Publish such material as may be developed in such form that it can be used by the industry.

GENERAL INDUSTRY APPLICATIONS SUBCOMMITTEES

This scope to apply to all subcommittees.

Scope—To stimulate and initiate engineering papers and discussions pertaining to electrical problems in the following named industries; to help organize technical sessions devoted to these problems at AIEE meetings; and, eventually, to promote standards and recommended practices in the electrical engineering field as far as this industry is concerned.

1. Machine Tools Subcommittee

2. Rubber and Plastics Industries Subcommittee

3. Pulp and Paper Industry Subcommittee

4. Textile Industry Subcommittee

5. Materials Handling Industry Subcommittee

INDUSTRIAL CONTROL SUBCOMMITTEES

1. Bibliography Subcommittee

Scope—To compile and prepare for publication a bibliography of pertinent American and foreign technical literature pertaining to the art of industrial control.

2. Electronic Control Subcommittee

Scope—The treatment of all matters in which the dominant factors are the design, construction, and functioning of electronic industrial controls exclusive of those controls and functions that specifically are assigned to other technical committees.

Working Groups:

(2-1). Electronic Control of D-C Motors
(2-2). Photoelectric Pickup Systems
(2-3). Electronic Relaying Devices
(2-4). Electronic Regulators and Regulating Systems
(2-5). Electronic Control of A-C Power

3. Standards Subcommittee

Scope—This subcommittee will prepare proposals for revised and new Standards, pertaining to industrial control, in which AIEE is interested. Such proposals are then submitted to competent AIEE committees empowered to take official action on such standards. The work of co-ordinating is carried on by the subcommittee chairman who assembles working groups from time to time as the need for action on existing or new Standards arises.

4. Test Codes Subcommittee

Scope—To develop test procedure and test methods for industrial control equipment, exclusive of routine or production tests.

INDUSTRIAL POWER SYSTEMS SUBCOMMITTEES

1. Subcommittee on Revision of Electric Power Distribution for Industrial Plants

MINING AND METAL INDUSTRY SUBCOMMITTEES

1. Metal Industries Subcommittee

2. Mining Subcommittee

SERVOMECHANISMS SUBCOMMITTEES

No subcommittees have been appointed as yet.

Power Group

CARRIER CURRENT SUBCOMMITTEES

1. Subcommittee for Preparation of a General Interest Paper on Carrier Current

Scope—This paper is to give an historical review of the carrier developments and outline the place the carrier has in present-day system operating practices.

2. Subcommittee to Report on Application Guidance for Carrier Current

3. Subcommittee on Methods Measurement

Scope—Establishment of methods of measurements in the carrier field.

4. Subcommittee on High-Frequency Characteristics of Power Equipment

5. Subcommittee on Carrier Current Characteristics of Transmission Lines and Systems

Scope—Power system measurements at carrier frequency dealing primarily with transmission lines and substations.

6. Subcommittee on Standard Terminology for Carrier Current

7. Subcommittee on Long Life Tubes

Scope—To obtain information on tube life, methods of extending life, and new technical developments in the art (this is a new subcommittee replacing the Working Group on Coupling Capacitors and Traps for Rural Line Carrier Telephone).

8. Subcommittee on Use of Microwave Equipment for Relaying, Telemetering, and Supervisory Control

9. Subcommittee on Operating Experience With Carrier Current Relaying Channels

INSULATED CONDUCTORS SUBCOMMITTEES

1. Administration Subcommittee

Scope—The activities of the Administration Subcommittee shall be directed to the administration of the policy and general affairs of the committee.

Included in its scope shall be: Selection of location, date, and operational plan of committee meetings; organization and scopes of subcommittees; co-ordination of subcommittee activities; planning of technical sessions for general meetings; approval of distribution of questionnaires; and approval of distribution to the committee membership of papers and publications published by other organizations.

The personnel of the subcommittee shall consist of the committee chairman, vice-chairman, secretary, past-chairman, and the subcommittee chairmen.

2. Standards and Publications Subcommittee

Scope—The activities of the Standards and Publications Subcommittee shall be directed to the compilation of general Standards, editing of technical Standards, and the preparation of publications and articles for publication under sponsorship of the committee.

Included in its scope shall be: Sponsorship of Standard 30, "American Standard Definitions and General Standards for Wire and Cable"; reference books, and bibliographies.

3. Cable Characteristics Subcommittee

Scope—The activity of the Cable Characteristics Subcommittee shall be directed to the physical properties, electrical characteristics, and factors related to the application and rating of insulated cables.

Included in its scope shall be: Calculation constants (such as, a-c resistance, reactance, zero-sequence impedance, thermal resistivity of cables, duct structures, and soil); cable loading; operating temperatures; sheath bonding; stress distribution; hydraulics of oil-pipe systems; lightning protection for aerial cables (joint with Lightning Protective Devices Subcommittee).

4. Conductors Subcommittee

Scope—The activity of the Conductors Subcommittee shall be directed to the physical construction of conductors used in insulated wire and cable.

Included in its scope shall be: Conductor materials, and conductor specifications (liaison with ASTM Committee B1 on Wires for Electrical Conductors).

5. Insulations Subcommittee

Scope—The activity of the Insulations Subcommittee shall be directed to the properties of dielectric materials used in insulated wire and cable, and their accessories.

Included in its scope shall be: Oil-impregnated paper; varnished cambric; thermosetting materials; thermoplastic materials; and inorganic materials (such as, asbestos, fiber glass).

6. Sheaths and Coverings Subcommittee

Scope—The activity of the Sheaths and Coverings Subcommittee shall be directed to the sheath, jacket, and covering materials used in insulated wire and cable.

Included in its scope shall be: Lead and lead alloys; jacket materials; electrolysis and corrosion (including liaison with NACE); protective coverings for lead sheaths; armors.

7. Cable Supply Systems Subcommittee

Scope—The activity of the Cable Supply Systems Subcommittee shall be directed to the transmission and distribution of bulk energy by means of insulated conductors whether underground in ducts or pipes or aerially on poles.

Included in its scope shall be: Impregnated-paper cable (solid, oil-filled, gas-filled, pressure types); nonmetallic-sheathed cable; aerial cable systems; buried cable systems; insulated line conductors (specifications).

8. Utilization Wiring Systems Subcommittee

Scope—The activity of the Utilization Wiring Systems Subcommittee shall be directed to the distribution of energy at utilization voltages by means of insulated conductors.

Included in its scope shall be: National Electric Code developments, wiring materials, and wiring systems such as a-c networks, bare-neutral, conduit-return).

9. Special-Purpose Cables Subcommittee

Scope—The activity of the Special-Purpose Cables Subcommittee shall be directed to construction and application of insulated conductors designed for special uses.

Included in its scope shall be: Shipboard cable; vertical-riser cable; mining cable; generator-lead cable; electric-furnace leads; collaborate on Standard 45 on "Recommended Practice for Electrical Installations on Shipboard" (Sections 18, 19, 20). (Co-operate with Marine Transportation Committee, sponsor.)

10. Accessories Subcommittee

Scope—The activity of the Accessories Subcommittee shall be directed to the design, construction, and application of equipment and appurtenances used with insulated conductors.

Included in its scope shall be: Sponsorship of Standard 48, "Cable Potheads"; terminations and potheads; joints; duct splices; filling compounds; oil reservoirs; alarm systems; network limiters; manhole switches.

11. Structures Subcommittee

Scope—The activity of the Structures Subcommittee shall be directed to the design, construction, and maintenance of structures used to support or enclose insulated cable systems and their appurtenances.

Included in its scope shall be: Conduit and ducts; manholes; transformer vaults; kiosks; terminal supports; marine and viaduct crossings.

12. Tests and Measurements Subcommittee

Scope—The activity of the Tests and Measurements Subcommittee shall be directed to the development of test methods particularly designed to determine the physical properties of electrical characteristics of insulated conductors and to evaluate their usefulness and life under service conditions.

Included in its scope shall be: Test codes; dielectric strength tests (a-c, d-c, impulse);

conductor measurements; dielectric measurements; corona measurements; installation testing; fault localization; operational testing.

POWER GENERATION SUBCOMMITTEES

1. Prime Movers Subcommittee

Scope—To study, review design, installation practices, and other features of all types of prime movers and their associated equipment (except hydraulic units) as related to electric power generation. To sponsor specifications, Standards, and technical sessions, the latter to be devoted principally to new developments or review of existing practices. To co-operate with other committees of organizations such as American Society of Mechanical Engineers and Edison Electric Institute.

2. Speed Governing Subcommittee

Scope—To study, review design, installation practices, and other features of all types of prime-mover governing systems, including hydroelectric. To sponsor specifications, Standards, and technical sessions and co-operate with other committees of the AIEE and other societies.

3. Excitation Systems Subcommittee

Scope—Similar functions as for the speed-governing subcommittee in the field of generating-station excitation systems.

4. Station Design Subcommittee

Scope—To review designs and installation practices in electric generating stations considered as a unit. To sponsor technical sessions covering new or improved practices. To analyze trends and designs and present general interest material of future possibilities. This subcommittee will not cover hydroelectric stations.

5. Hydroelectric Systems Subcommittee

Scope—Combining the scope for hydroelectric stations only, of the prime movers and station design subcommittees.

6. Pacific Coast Subcommittee

Scope—To foster closer co-operation with the western members in all projects undertaken by the main committee. To provide direct contact in the planning of Pacific Coast technical meetings.

PROTECTIVE DEVICES SUBCOMMITTEES

1. Fault Limiting Devices Subcommittee

Scope—To study the theory, review installation practices, prepare general application guides, summarize the literature, sponsor technical papers, and interpret the practical and theoretical functioning of power system current and voltage limiting devices and methods. To prepare Standards and definitions on fault limiting devices and methods.

The devices include power system neutral grounding devices, grounding transformers, series current limiting reactors, and so forth. The methods of fault limitation include arrangements of circuits and grounding of neutrals, regardless of whether grounding devices or series reactors are used.

Project 1—Application Guide for the Grounding of Synchronous Generator Systems.

Project 2—Application Guide for the Grounding of Transmission Systems.

Project 3—Guide for Application of Ground Fault Neutralizers.

Project 4—Bibliography of Literature of Grounding Devices.

Project 5—Field Survey of Unbalanced Charging Currents.

Project 6—Power System Fault Limitation.

2. Lightning Protective Devices Subcommittee

Scope—Treatment of all matters in which the dominant factors are the design, construction, application, and operation of devices and equipment to limit or prevent damage to electric power generation, transmission, or distribution systems, or equipment; such damage arising from lightning. Included in this scope shall be treatment of the following:

Lightning arresters (including the devices which have been or are commonly known as valve arresters, expulsion arresters, protector tubes, and expulsion gaps).

Rod gaps, and so forth.

Fused gaps (one shot and repeater types).

Wave sloping capacitors.

Lightning rods and masts.

Overhead ground wires in so far as used for lightning protective purposes.

Counterpoises in so far as used for lightning protective purposes.

The general terms design, construction, application, and operation as applied to lightning protective devices are interpreted to include theory, nature, and character of materials as affecting performance, preparation of Standards and definitions of ratings, classification, functional possibilities and limitations in relation to system characteristics and to other protective devices, resistance of earthing connections, effect of location with respect to protected equipment, effect of rating as bearing on performance of the devices, methods of field testing and maintenance, records of field performance as affecting design and application, and field and laboratory research with natural and artificial lightning and their effect on the design, construction and operation of lightning protective devices.

Project 1—Application Guide for Lightning Protection of Substations.

Project 2—Revision and combination of AIEE Standards 24, "Protective Tubes"; 28, "Lightning Arresters for A-C Power Circuits"; and 47, "Expulsion-Type Distribution Lightning Arresters."

Project 3—Performance Characteristics of Lightning Protective Devices.

Project 4—Recovery Voltage Characteristics of Distribution Systems.

3. Co-ordination of Insulation Subcommittee

Scope—This subcommiitee was established to handle problems within the Protective Devices Committee dealing with co-ordination of insulation. Its function has been to keep the members of the Protective Devices Committee informed concerning the activities of other committees that are doing work dealing with insulation co-ordination.

RELAYS PROJECT COMMITTEES

1. Bibliography of Relay Literature Project Committee

Scope—This committee prepares lists of references to publications on relaying in the American and foreign press. Periodically (about every three years) these lists are published as formal AIEE papers.

2. Generator Protection Project Committee

Scope—This committee is studying the problem of generator protection with the objective of writing a report covering the present accepted methods. It has been investigating many special problems, such as loss of excitation and partial winding faults.

3. Co-ordination of Construction and Protection of Distribution Circuits (Joint with Distribution Subcommittee and Edison Electric Institute).

Scope—This is a joint group consisting of members of the AIEE Relay Committee, AIEE Transmission and Distribution Committee, and the EEI. This committee is studying the co-relation of distribution circuit construction and protection practices. The purpose is to collect performance data on representative distribution circuits to study the effects of various construction and protection details on the quality of service rendered by the distribution circuits.

4. Revision of Standards for Power Relays Project Committee

Scope—This committee was organized for the purpose of revising ASA Standard *C-42*, "American Standard for Relays Associated with Electric Power Apparatus." This revision was completed recently, but the committee will continue to function for the purpose of determining what information on performance data should be incorporated in a future revision of the Standard.

5. Insulation Levels of Relays and Control Circuits Project Committee

Scope—This committee has investigated the insulation levels required for safe operation of protective relays. The paper is in the process of preparation to present to AIEE the recommendations of the project committee with regard to adequate insulation levels.

6. Sensitive Ground Protection Project Committee

Scope—The protection against low current faults presents a special and difficult problem. This committee was organized to review available methods of providing such protection. A final report will be available from this committee in the near future.

7. Transmission Line Protection Project Committee

Scope—This group is studying various methods of transmission line protection, and presenting to the Institute data which will aid relay engineers in providing the most desirable form of protection on transmission lines.

8. Electronic Relay Applications Project Committee

Scope—This committee is following the developments in the field of electronic relays for the purpose of bringing to the attention of the Institute new equipment or new ideas in this field.

9. Relaying of Interconnections Between Industrial and Utility Generating Systems Project Committee

Scope—This project committee is investigating the special relay problems encountered in the parallel operation of industrial generating systems with larger interconnected power systems.

10. Relaying Performance of Current Transformers Project Committee (Emphasis on High Impedance Secondary Types)

ROTATING MACHINERY SUBCOMMITTEES

1. *Administrative Subcommittee*
2. *Synchronous Machinery Subcommittee*
3. *Induction Machinery Subcommittee*
4. *D-C Machinery Subcommittee*
5. *Single-Phase and Fractional-Horsepower Subcommittee*
6. *Test Code Subcommittee*
7. *Insulation Resistance Subcommittee*

SUBSTATIONS SUBCOMMITTEES

1. *Executive Subcommittee*

Scope—To plan and co-ordinate the activities of the main committee and its subcommittees including consideration of their scopes, program planning, and assistance in selection of papers.

2. *Transmission Substation Subcommittee*

Scope—Responsible for treatment of all problems relating to design, construction, and arrangement of transmission substations.

3. *Distribution and Conversion Substation Subcommittee*

Scope—Responsible for treatment of all problems relating to design, construction, and arrangement of indoor and outdoor distribution and conversion substations.

4. *Automatic and Supervisory Control Subcommittee*

Scope—Responsible for treatment of problems relating to the development and application of automatic, remote, and manual control of all substations and similar automatic and remote control features of electric generating stations.

Working Groups—1. Working Group on Device Function Numbers. 2. Working Group on Rectifier Switchgear. 3. Working Group on Substation Grounding.

SWITCHGEAR SUBCOMMITTEES

1. *Circuit Breaker Subcommittee*
2. *Switchgear Assemblies Subcommittee*
3. *Switches, Fuses, and Insulators Subcommittee*
4. *Subcommittee on High-Voltage Switching (Where Out-of-Phase Voltages Exist at Time of Arc Interruption)*

SYSTEM ENGINEERING SUBCOMMITTEES

1. *Administrative Subcommittee*

Scope—To serve as an executive committee in the assignment of work to subcommittees, to expedite work and to arrange for preparation and presentation of papers at meetings.

2. *System Planning Subcommittee*

Scope—Investigation and study of load growth and generation requirements, interconnection of systems, methods of transmission and interconnection, location and optimum sizes of units, and general system planning studies.

3. *System Operations Subcommittee*

Scope—Investigation and study of load and kilovar dispatching, spinning reserve, emergency procedures, resynchronizing procedures, requirements and usage of communication equipment, safety "hold-off procedures," functions of intersystem operating committees, and other general studies for improvement of system operation.

4. *System Economics Subcommittee*

Scope—Investigation and study of interconnection operation, economics of long high-voltage power transmission, co-ordination of operation of units in a plant, between plans in a system, and between systems and other economic studies for improved system operation.

5. *System Controls Subcommittee*

Scope—Investigation and study of load-frequency control equipment and operation, voltage control, phase angle control, and other general studies of control methods to improve system operations.

6. *Interconnection Contracts Subcommittee*

Scope—Investigation and study as to important features of interconnection contracts, economic interchange, emergency requirements and metering requirements, and other matters of interest to improve interconnection relations.

TRANSFORMERS SUBCOMMITTEES

Working Groups—

Subject 5: Co-ordinated Study of Life of Transformer Insulation

Subject 9: Instrument Transformers

Subject 10: AIEE Papers

Subject 19: Short-Circuit Thermal Ratings of Induction and Step-Type Regulators

Subject 20: Magnetization Characteristics of Transformers

Subject 21: Revision of Dielectric Tests

Subject 24: Guides for Operation and Maintenance of Dry-Type Transformers with Class *B* Insulation

Subject 25: Co-ordination of Insulation

Subject 27: Electronic Power Converters

Subject 28: Methods of Making Heat Runs

Subject 29: Power Factor Measurements

Subject 30: Audible Noise in Transformers

TRANSMISSION AND DISTRIBUTION SUBCOMMITTEES

1. *Capacitor Subcommittee*
2. *Distribution Subcommittee*
3. *General Systems Subcommittee*
4. *Lightning and Insulator Subcommittee*
5. *Towers, Poles, and Conductors Subcommittee*

Science and Electronics Group

BASIC SCIENCES SUBCOMMITTEES

1. *Applied Mathematics Subcommittee*

Scope—To furnish needed co-operation between mathematicians and engineers, preferably by bringing specific engineering problems to the attention of mathematicians for solution rather than to consider only general problems which might be discussed from an abstract viewpoint. Members of the American Mathematical Society are invited to join with this subcommittee in mutually advantageous conferences and sessions.

2. *Electric Circuit Theory Subcommittee*

Scope—Considerable work in circuit theory has been done, particularly as a result of the war effort. The function of this subcommittee is to make a thorough review of recent circuit theory developments in all fields directed toward the publication of this material and also to study circuit theory definitions which are needed urgently in view of the almost complete lack of standard circuit theory definitions existing at the present time.

3. *Energy Sources Subcommittee*

Scope—The great impetus given to new methods of supplying electric power by developments to nuclear energy has suggested that all known methods of producing electric power should be reviewed in the light of present-day knowledge. This subcommittee is conducting conferences to review the various known means of electric energy generation, efforts being made to prepare for publication of papers by outstanding experts in their respective fields.

4. *Electrical Properties of Solids and Liquids Subcommittee*

Scope—To acquaint engineers with recent investigations in physics, chemistry, and mathematics dealing with the electrical properties, early stage applications, and theories of solid and liquid materials used in electrical engineering; these materials include metals, semiconductors, dielectrics, and liquids.

5. *Subcommittee on Magnetics*

Scope—Treatment of theories relating to magnetism and of the development and application of magnetic materials; co-operation with other societies on such subjects as magnetic nomenclature and testing.

6. *Subcommittee on the Electrical Properties of Gases*

Scope—To keep abreast of the latest developments in this field and to bring before the Institute such papers and speakers as are deemed necessary to co-ordinate the fundamental and theoretical work being carried on (in many cases by physicists) with the applied work of various Institute technical committees.

COMPUTING DEVICES SUBCOMMITTEES

1. *Continuous-Variable Computers Subcommittee*

Scope—The treatment of all matters in which the dominant factors are the requirements, design, construction, selection, installation, scope, and operation of machinery and devices relating to computing devices of the continuous-variable type, that is, to devices in which each problem quantity is represented by the magnitude of some computer quantity such as, for example, a shaft rotation or a voltage. This includes studies of the electromagnetic, electronic, and mechanical phenomena of such devices. In particular a great many, though not all, of the continuous-variable computers are based on analogy with the physical system to be studied so that this subcommittee will be concerned with all such analogy computing devices.

2. *Digital Computers Subcommittee*

Scope—The treatment of all matters in which the dominant factors are the requirements, design, construction, selection, installation, scope, and operation of machinery and devices relating to computing devices in which the problem quantities involved are represented in the computer by the digital number system. This includes studies of the electromagnetic, electronic, and mechanical phenomena of such devices.

ELECTRONIC POWER CONVERTERS

1. *Administrative Subcommittee*

Scope—The function of this subcommittee is to plan and co-ordinate the activities of the main committee and its subcommittees. It will consist of the officers and the preceding chairman of the main committee, the chairmen of the subcommittees, and any other committee members designated by the chairman.

2. Electronic Converter Application Subcommittee

Scope—This subcommittee will handle matters relating to the application and operation of electronic power converters, such as rating, installation, operation, maintenance, inductive co-ordination.

3. Electronic Converter Circuits Subcommittee

Scope—This subcommittee will handle matters relating to circuit theory, protection, and control of electronic power converters. It will co-operate with other subcommittees and with other AIEE committees (such as Electronics, Switchgear, Protective Devices, Substations) on matters of mutual interest.

4. Papers and Speakers Subcommittee

Scope—This subcommittee will complete the bibliography on electronic power converters and will keep it up to date with annual supplements. It will make recommendations on subjects of technical papers and promote the preparation of such papers. It will prepare information on the availability of speakers and educational material on electronic power converters, as an aid to schools, AIEE Sections, and discussion groups.

5. Rectifier Transformers Subcommittee

Scope—This subcommittee will handle matters relating to transformer equipment used for electronic power converters. It will maintain liaison with the AIEE Transformer Committee, to keep the two committees informed on matters of mutual interest.

6. Rectifying Devices Subcommittee

Scope—This subcommittee will handle matters relating to design and characteristics of rectifying devices used for electronic power converters. It will maintain liaison and co-operate with other technical committees of the AIEE and other organizations which carry on activities relating to such rectifying devices, and it will keep the electronic power converter committee informed on such activities.

7. West Coast Subcommittee

Scope—This is a regional subcommittee operating within the scope of the main committee. Its functions are to encourage and co-ordinate AIEE activities relating to electronic power converters in the West Coast region, to keep members informed on electronic power converter developments, to maintain contact with the main committee and its other subcommittees, and to participate in their activities that are of interest to the West Coast region.

8. Hot-Cathode Power Converter Subcommittee

Scope—Preparation of Standards that apply to the following types of converters: Rectifiers utilizing hot cathode gas or vacuum tubes and inverters utilizing hot cathode gas tubes. This scope excludes applications in oscillator circuits and radio receivers.

ELECTRONICS SUBCOMMITTEES

1. Electronic Aids to Navigation Subcommittee

Scope—To keep the Electronics Committee informed of progress in this field, and where appropriate, to inform AIEE membership of important developments by publication in AIEE channels.

2. Electronic Precipitation Subcommittee

Scope—Electrical precipitation of dust, both in air conditioning and in the removal of high concentrations of dust fume and smoke which generally has been called Cottrell precipitation; electrostatic painting and "detearing"; electrostatic separation, screening, and grading of solids; electrostatic application of abrasives and other substances in manufacturing processes; electrostatic printing; static problems in industry.

3. Electronic Papers, Meetings, and Section Contacts Subcommittee

Scope—Encourages and initiates the preparation of papers on any phase of electronics.

4. High-Frequency Conductors, Cables, and Connectors Subcommittee

Scope—The subcommittee has under consideration possible standardization, procurement of technical papers, and liaison work with other technical committees in connection with high-frequency cables, conductors, and connectors.

The scope of this subcommittee also will include wave guides. The subcommittee has been actively considering coaxial cables, other high-frequency wires and connectors, and test methods.

5. Subcommittee for Liaison with IRE

Scope—Liaison representative to provide co-ordination between electronics committee and groups in the Institute of Radio Engineers interested in same field.

6. Subcommittee for Liaison with JETEC (Joint Electron Tube Engineering Council)

Scope—The function of this subcommittee is to co-ordinate activities on electron tubes, particularly from a standpoint of preventing duplication and seeing that the work of each group is suitable for use by the other groups.

7. Education Subcommittee

Scope—This subcommittee was formed to co-ordinate the work of the Electronics Committee with electrical engineering education; to aid electrical engineering educators in the teaching of electronics, and to help in introducing the advances in the field in to the schools in an orderly and desirable manner. Conversely, the committee acts to inform the Electronics Committee and the AIEE of advances in education produced by the impact of electronics on the electrical engineering field. The committee also provides liaison with the Education Committee.

8. X-Ray Tubes, Apparatus and Applications

Scope—Matters pertaining to X-ray tubes, rectifier tubes used in X-ray high-voltage generators, and other electron tubes used in X-ray apparatus and accessories; industrial applications of X rays; and engineering connected with X-ray equipment. The committee is concerned with the preparation of Standards such as graphical symbols for electron devices, standard definition of electrical terms, particularly those related to X-ray equipment. It contemplates work on such projects as standardizing the method of specifying the ratings and characteristics of X-ray and rectifier tubes; standardizing the symbols and form of presenting the wiring diagrams for X-ray generators; and standardizing the method of specifying the characteristics and ratings of X-ray transformers and generators. It also will consider the engineering phases of the industrial application of X rays.

9. Electron Tube Subcommittee

Scope—Treatment of all technical matters relating to electron tubes for industrial use. The committee, through four working groups, is engaged in the preparation of Standards on high vacuum, cathode-ray, photo, gas-filled, and pool-cathode tubes.

Working Groups—

(9–1). High Vacuum Tubes

(9–2). Cathode-Ray Tubes

(9–3). Gas-Filled Thermionic and Cold Cathode Tubes—Phototubes

(9–4). Mercury-Pool Cathode Tubes

10. Electronic Standards and Definitions Subcommittee

Scope—It is the function of this subcommittee to assist the various electronic subcommittees in co-ordinating their standardizing efforts and to get them into the proper form and channels, if they are to become AIEE or American Standards. A part of this subcommittee's function is education, in that it is attempting to show how standardization is accomplished, what national societies and associations are concerned, and how their activities are correlated.

11. Electronic Aids to Geophysics

Scope—A series of technical symposia of interest to the electronic engineers in geophysics is being conducted in Houston, Tex. The purpose of the meetings is to bring together for group study and discussions the electronic specialists scattered throughout the various geophysical laboratories of the petroleum industry. It is hoped that this program will not only improve the technical ability of the individuals, but that it will stimulate the writing and publication of technical papers, the development of Standards, and a wider exchange of technical knowledge and methods. Following a trial period in Houston it is planned to initiate similar meetings in other areas of geophysical activity.

12. Electronic Preparation and Preservation of Food Subcommittee

Scope—Usual technical subcommittee activity with special emphasis on papers to be published on "Electronic Preparation and Preservation of Food."

13. Infrared Applications Subcommittee

Scope—Encourages interchange of information; publication of infrared advancements; use of standard nomenclature, and adoption of standards of specifications, of testing, and of measurements in the field of infrared radiation; and, in particular, pursue measuring devices and their applications, observation and detection equipments, spectroscopy instrumentation including process control and spectral characteristics of chemical materials and optical materials relative to their use in spectroscopy instrumentation in liaison with other societies.

14. Liaison With Nucleonics Subcommittee

Scope—Maintenance of adequate interchange of information, as to objectives and activities, between the Electronics Committee and other AIEE groups interested in problems of nuclear instrumentation and nuclear power.

15. Magnetic Amplifier Subcommittee

Scope—Fundamental development, design, and application of magnetic amplifiers and

of materials and components as specifically used. Standardization of definitions, nomenclature, symbols, and operating characteristics. Encouragement of the exchange of information as by technical papers, conference sessions, and demonstrations.

16. Applications of Semiconductor Devices Subcommittee

Scope—Treatment of all technical matters relating to the engineering development, manufacture, and application of semiconductor devices. Standardization of definitions, nomenclature, symbols, and operating characteristics. Organization of technical sessions and conferences, stimulation and review of technical papers.

17. Electronic Heating Liaison

Scope—Maintaining adequate interchange of information, as to objectives and activities between the Electronics Committee and other AIEE groups interested in induction and dielectric heating.

INSTRUMENTS AND MEASUREMENTS SUBCOMMITTEES

1. Subcommittee on Instruments and Measurements Organization

Scope—To plan and co-ordinate the activities of the main committee and its subcommittees, including consideration of their scopes, organization, and also to determine committee policy with particular reference to adequate liaison with other technical committees and other technical organizations.

2. Subcommittee on Revision of Standard 4 (Measurement of Test Voltage in Dielectric Tests)

Scope—The scope of this subcommittee includes the establishment of standard methods of measurement of high-voltage for a-c potentials, d-c potentials, and impulse potentials; and the specifying of the construction details, calibration values, and methods of use of sphere spark gaps, potentiometer, oscillographs, and the like necessary for the foregoing.

3. Subcommittee on Watt-hour Meters

Scope—The function of this subcommittee is to encourage the writing of papers on the general subject of the measurement of electric energy and the engineering aspects of apparatus to accomplish such measurements, suitable for presentation before meetings of the Institute or for publication in *Electrical Engineering;* to bring to the attention of those engaged in the field of such measurements significant scientific and engineering developments; and to co-operate with other interested groups in order that the art may be advanced.

4. Subcommittee on Definitions

Scope—The function of this subcommittee is to study the definitions appearing in Institute or ASA Standards and codes, particularly the *C42* Definitions of Electrical Terms, which have reference to electrical instruments or measurements, with the object of correcting any inaccuracies of improving the definitions, particularly in the light of later developments in the art; to originate new definitions which developments in the art of instruments and measurements make desirable, and to pass judgment on any new definitions which may be submitted by Institute members or others; to work toward the co-ordination of the definitions of the Institute with those of other technical or standardizing organizations such as IRE, ASA, and so on; to submit all revised and new definitions on which action has been taken to the Instruments and Measurements Committee with recommendations.

5. Subcommittee on Dielectric Measurements in the Field

Scope—The function of this subcommittee is to formulate Standards on dielectric measurements in the field and to foster interest and technical publicity in this field.

6. Subcommittee on Master Test Code for Temperature Measurements

Scope—The function of this subcommittee is the production of a new test code covering the determination of temperature and of temperature rise in electrical measurements and apparatus. The subcommittee has drawn up a proposed code which has been accepted by the Instruments and Measurements Committee and is to be printed for trial use.

7. Subcommittee on High-Frequency Measurements

Scope—The function of this subcommittee is to promote interest among members of the Institute in the field of high-frequency measurements. This field includes all frequencies above the audio range with special emphasis on the higher radio frequencies where the more recent developments in the art are found. In furtherance of this aim the subcommittee is sponsoring papers and conferences on the subject of high-frequency measurements and expects to consider Standards in this field.

8. Subcommittee on Marking of Varmeters and Related Instruments

Scope—The function of this subcommittee is to study the uses to which varmeters and related instruments are put and to develop standard connections and markings which would meet the requirements of users. This has a bearing on the change in the sign of reactive power.

9. Instruments and Measurements Co-operation with Instrument Society of America Subcommittee

Scope—To plan sessions to be conducted at the Instrument Society of America's Annual Exhibit in co-operation with ISA and AIEE local Sections.

METALLIC RECTIFIERS SUBCOMMITTEES

Working Groups—

(1). Standard Definitions
(2). New Definitions
(3). Bibliography
(4). Test Standards
(5). Patent Bibliography
(6). Papers and Speakers
(7). Miniature Rectifiers

NUCLEONICS SUBCOMMITTEES

1. Studies of Nuclear Theory

2. Isotopic Tracers

Scope—To sponsor papers and articles and to co-operate with other technical committees of the AIEE in the field of isotopic tracers, including: Techniques for preparation, purification, standardization, and chemical synthesis of radioactive and stable tracer isotopes and their compounds; the application of these tracers in scientific research, engineering, and industrial process control.

THERAPEUTICS SUBCOMMITTEES

No subcommittees have been appointed as yet.

Joint Subcommittees

1. Joint Subcommittee on Application of Probability Methods to Power-System Problems (Joint with Power Generation and System Engineering Committee)

Scope—To study, review, and foster the techniques of probability methods in rational design of power systems for electrical generation. To sponsor technical sessions covering the application of probability methods. To co-operate with other AIEE committees, professional societies, and technical organizations in collecting and analyzing performance data needed in the application methods.

2. Joint Subcommittee on Carbon Brushes (Joint with AIEE Rotating Machinery and Air Transportation Committees and NEMA)

Scope—The purpose of this joint subcommittee on carbon brushes shall be: To prepare standard codes for testing carbon brush materials and brushes; to encourage research and development which may lead to improved brush performance; to encourage the preparation of technical papers relating to the manufacture, application, and operation of carbon brushes, and to promote conferences and technical meetings at which such papers shall be presented.

3. Joint Subcommittee on Nucleonic Instruments (Joint with Nucleonics and Instruments and Measurements Committee)

Scope—Treatment of all matters pertaining to the design, construction, and application of devices used for the detection and measurement of nucleonic radiations. The activity of the subcommittee in this field will include:

1. Sponsorship of papers of two general kinds, namely, survey papers of a broad educational nature and descriptive papers covering developments primarily of interest to the membership.

2. Sponsorship of conference sessions on similar subjects.

3. Co-operation with the various existing committees of the AIEE and other organizations, particularly with respect to standardization and definitions. (In this latter instance, it is believed this subcommittee's efforts initially will be by way of review and suggestion.)

4. Joint Subcommittee on Electronic Instruments (Joint with Electronics and Instruments and Measurements Committee)

Present Activities:

1. Preparation of standard specification forms with cathode-ray instruments and electronic voltmeters. These forms will standardize methods for specifying performance and other information concerning these instruments. Where necessary, a glossary of preferred terms with definitions will be included.

2. Continuing a program of liaison between instrument manufacturers, tube manufacturers, component manufacturers, and other groups interested in improved electron tubes and other components for electronic instruments and industrial equipment.

3. To solicit, review, and sponsor technical papers and reports on electronic instruments.

Proposed Future Activities:

1. Extension of the work on standard specification forms to other electronic instruments.

5. *Joint Subcommittee on Telemetering (Joint with Instruments and Measurements, Carrier Current, and Substations Committees)*

Scope—Sponsorship of papers and sessions on telemetering, including new types of telemetering equipment, reports of installations and operating experience; interest in definitions of telemetering terms included in ASA Standard *C42* now in process of revision; study of developments in the field of mobile telemetering.

6. *Joint Subcommittee on Electrical Aids to Medicine (Joint with Electronics, Instruments and Measurements, and Therapeutics Committees)*

Scope—This subcommittee will attempt to co-ordinate medical and engineering development, acquainting the engineering profession with medical problems requiring engineering development, and acquainting the medical profession with possibilities in the solution of their problems.

AIEE Technical Subcommittees—1949–50

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Omar Wally — Cleveland, Ohio
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No subcommittees

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(*1*). Catenary overhead systems
(*2*). Third rail systems
(*3*). Electric locomotives
(*4*). Substations
(*5*). Power supply

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Industry Group

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Industrial Control

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OF CURRENT INTEREST

Establishing Co-operation Between Power Industry and AEC is New Committee's Aim

The United States Atomic Energy Commission recently announced the establishment of a 3-man temporary Advisory Committee to recommend ways to establish continuing co-operation between the electric power industry and the AEC. It is expected that the committee will study the Commission's reactor program with a view to identifying areas or potential areas of mutual interest to the electric power industry and the Commission and make recommendations for bringing about a continuing program of co-operation in these areas.

Members of the committee are Philip Sporn (A '20, F '30), Chairman, Edward W. Morehouse, and Walton Seymour. All three have had long records of public service in the electric power field.

Mr. Sporn, of New York, N. Y., is President of the American Gas and Electric Company and the American Gas and Electric Service Corporation. He is President and Director of the Ohio Power Company, Appalachian Electric Power Company, Indiana and Michigan Electric Company, and other operating companies of the American Gas and Electric Company system.

Mr. Morehouse is Vice-President of the General Public Utilities Corporation in New York, N. Y. Now a consultant to the National Security Resources Board, he is a Director of the Jersey Central Power and Light Company, Associated Electric Company, Pennsylvania Electric Company, Rochester Gas and Electric Corporation, Metropolitan Edison Company, and New Jersey Power and Light Company.

Walton Seymour, of Washington, D. C., is Director of the Division of Power in the Secretary's Office, United States Department of the Interior, and is a principal figure in electric power administration for the Federal Government. He is also Director, Program Staff, Office of the Secretary, United States Department of the Interior.

Members of the new committee, who have been cleared for access to whatever data in the reactor field they may need to carry out the project, will conduct a first-hand examination of programs and technical information in the AEC's reactor development program. It is expected that the survey will be completed and recommendations submitted by March 31, 1950.

The 3-man committee will make recommendations as to the need for establishing a permanent advisory committee for the electric power industry and suggestions as to membership on any continuing advisory or liaison body with the power industry that might be desirable to implement the proposals of the ad hoc committee.

It is hoped that a program may be devised for contacts between the electric power industry and the Commission which will give to appropriate groups in the industry an understanding of the problems involved in the Commission's nuclear reactor development work, thus enabling the industry to participate in properly defined areas of that work and to utilize its specialized technological resources to contribute to the solution of problems in this field for the mutual advantage of the Commission, the power industry and the general public. It is also hoped that through this program it will be possible to identify declassified and further declassifiable technical information regarding reactor development which may be useful to the industry as a whole.

M. Schiesser, Head of Swiss Firm, Elected to Presidency of IEC

Dr. Max Schiesser, head of the Brown Boveri Company at Baden, Switzerland, and president of the Swiss Electrotechnical Institution since 1939, has been elected president of the International Electrotechnical Commission. Dr. Schiesser succeeds E. Uytborck of Belgium.

As president of the IEC, he heads the international organization which has been responsible for correlating opinion on electrical problems in 25 member countries and which is credited with bringing about a large degree of standardization and interchangeability in electrical products throughout the world. The IEC is now the electrical section of the International Organization for Standardization.

Dr. Schiesser has been with the firm of Brown Boveri since 1901 except for a short period during which he worked in France and in the United States. He is credited with important contributions to the development of rotary converters, mercury arc rectifiers, and switchgear.

The International Electrotechnical Commission was organized in 1906 to act as a permanent "world congress" on electrical problems. It now has 25 countries in its membership. Opinion on international electrical problems is correlated in each member country through a National Committee, which represents all sections of that country's electrical industry.

In this country the United States National Committee performs this function. This committee operates through the American Standards Association. Dr. H. S. Osborne (A '10, F '21), Chief Engineer of the American Telephone and Telegraph Company, New York, N. Y., is the chairman of the committee; P. H. Chase (A '12, F '43), Chief Engineer of the Philadelphia (Pa.) Electric Company and Frank Thornton, Jr. (A '10, F '21), Engineering Manager, Association Activities, Westinghouse Electric Corporation, East Pittsburgh, Pa., are the vice-presidents; G. F. Hussey, Jr. (Vice-Admiral, United States Navy, retired), Secretary of the American Standards Association, is the treasurer; and J. W. McNair (A '25) of the ASA staff is secretary.

NBS Color Television Committee to Conduct Survey for Johnson

At the request of United States Senator Edwin Johnson of Colorado, the National Bureau of Standards has organized a Color Television Committee for the purpose of

Large A-C Calculating Board

Latest and largest a-c calculating board built by the Westinghouse Electric Corporation was installed recently for the Pacific Gas and Electric Company. It makes calculations involving load division, relaying, stability, and the like, solving problems of operating high-voltage transmission lines between the company's hydroelectric generating stations

surveying the present status and future prospects of color television. The committee will confine its attention to the scientific and technical phases of the problem and will present a report to Senator Johnson in his capacity as chairman of the Senate Committee on Interstate and Foreign Commerce. Among other things this committee is concerned with problems of general policy in the radio communications field.

The membership of the National Bureau of Standards Color Television Committee is as follows:

E. U. Condon, Director, National Bureau of Standards—Chairman.

Newbern Smith, Chief, Central Radio Propagation Laboratory, National Bureau of Standards—Vice-Chairman.

Stuart L. Bailey, Consulting Engineer of Washington, D. C., and President of the Institute of Radio Engineers.

W. L. Everitt, Dean, College of Engineering, University of Illinois, Urbana.

Donald G. Fink, Editor, *Electronics*.

The general scope of the study by the National Bureau of Standards committee is indicated by the following tentative list of topics to be covered:

1. The situation concerning necessary band width for suitable color pictures.

2. The situation concerning present and near-future prospective development of color television transmitting and receiving equipment.

3. The situation concerning radio propagation factors in the 174–216-megacycle band (in the so-called very-high-frequency band) and the 470–890-megacycle band (in the so-called ultrahigh-frequency band) as affecting basic technical principles of frequency allocation for color television service.

4. The situation concerning adaptability of present television receivers to color use, or to receive in black-and-white a program being transmitted in color.

The committee expects to visit all industrial laboratories where work in the color television field is going on and to confer with research workers and specialists in the field. Its present aim is to provide a report for the use of the Senate Committee on Interstate and Foreign Commerce during next November, but this is, of course, subject to change if circumstances make it necessary.

AT&T Subsidiaries to Operate Sandia Laboratory of AEC

The United States Atomic Energy Commission has obtained the services of the Western Electric Company and the Bell Telephone Laboratories for the operation of the Sandia Laboratory at Sandia Base, Albuquerque, N. Mex. Negotiations have been started on a contract for these services with the Western Electric Company, equipment manufacturing subsidiary of the American Telephone and Telegraph Company. The new operator of the laboratory will have an important function in bridging the gap between laboratory development work and the manufacturing operations on atomic weapons.

The Sandia Laboratory has been operated since 1945 by the University of California under its contract for the operation of the Los Alamos Scientific Laboratory. Sandia has grown from a small liaison group representing Los Alamos into a major facility. The University of California advised the Commission last winter that the university felt it should not continue to manage Sandia as a part of the scientific research program of the Los Alamos Laboratory.

The growth of the Sandia Laboratory has been a result of the Commission's efforts to integrate research, development, and production activities in accordance with best academic and industrial practice. Thereupon, the Commission decided to ask the American Telephone and Telegraph Company to make available to this project the resources of the Bell System's developmental and manufacturing subsidiaries.

A special team of Western Electric, Bell Laboratories, and Atomic Energy Commission officials will go to Sandia immediately to prepare for the transfer of the project to the new contractor. Included in the group are: Stanley Bracken, President, Fred R. Lack (M '37), Vice-President (Radio Division), and G. A. Landry, Operating Manager of Installations, of Western Electric; Dr. Mervin J. Kelley, (M '26, F '31), Executive Vice-President and Donald A. Quarles (A '23, F '41), Vice-President in Charge of Staff, Bell Laboratories; and Brigadier General James McCormack, Jr., Director, Division of Military Application, Atomic Energy Commission.

Eta Kappa Nu Officers. Results of recent Eta Kappa Nu elections are as follows: Frank E. Sanford (F '46) was elected National Vice-President; A. B. Zerby (A '38) was re-elected Executive Secretary; Robin Beach (F '35), last year's Vice-President, will be the National President; Dr. Eric T. B. Cross (F '48), Dr. E. B. Kurtz (F '29), and K. L. Wildes (F '40) were elected members of the National Advisory Board; T. W. Williams (A '40) and N. S. Hibshman (F '41) past Presidents of the association, are members of the National Advisory Board.

Color, High-Speed Photography, Features of SMPE Fall Program

Latest advances in the techniques involved in making color motion pictures and in high-speed photography will receive major attention in papers scheduled for the 66th semiannual convention of the Society of Motion Picture Engineers at the Hollywood Roosevelt Hotel, in Hollywood, Calif., October 10–14. Four sessions on color and three on high-speed photography have been scheduled.

An expert on motion picture color will address the opening luncheon at the hotel Monday noon, and an authority on television will speak at a special television session to be held Thursday evening in the Carnegie Assembly Hall at the Mount Wilson Observatory. The latter session, one of the outstanding features of the convention, will follow a Thursday afternoon field trip to Mount Wilson, during which members and guests will have the opportunity to inspect television transmitters located there and the famed 100-inch telescope at the observatory.

At a business meeting preceding the opening technical session Monday afternoon members will discuss the proposed new constitution for the SMPE and the proposal to change the organization's name to the "Society of Motion Picture and Television Engineers," first disclosed at the Spring meeting in New York. The society's Progress Medal, Samuel L. Warner Memorial Award, and Journal Award, recognizing exceptional achievements in the industry, will be presented at the semiannual banquet, to be held in the Blossom Room of the Roosevelt Hotel, Wednesday night, October 12.

Future Meetings of Other Societies

American Association for the Advancement of Science. 116th Annual Meeting. December 26–31, 1949, Hotels Statler, Governor Clinton, New Yorker, McAlpin, and Martinique, New York, N. Y.

American Gas Association. Annual Convention. October 17–20, 1949, Palmer House, Morrison Hotel, and Sherman Hotel, Chicago, Ill.

American Institute of Chemical Engineers. National Meeting, December 4–7, 1949, William Penn Hotel, Pittsburgh, Pa.

American Institute of Mining and Metallurgical Engineers (Coal Division)–American Society of Mechanical Engineers (Fuels Division). 12th Joint Meeting. October 26–27, 1949, French Lick Springs Hotel, French Lick, Ind.

American Society of Mechanical Engineers. Annual meeting. November 27–December 2, 1949, Hotel Statler, New York, N. Y.

American Society for Testing Materials. West Coast Meeting. October 10–14, 1949, Fairmount Hotel, San Francisco, Calif.

American Standards Association. Annual Meeting. October 11–14, 1949, Waldorf-Astoria Hotel, New York, N. Y.

Audio Engineering Society. First Annual Audio Fair. October 27–29, 1949, Hotel New York er, New York, N. Y.

Engineers' Council for Professional Development. October 28–29, 1949, Edgewater Beach Hotel, Chicago, Ill.

Exposition of Chemical Industries. November 28–December 3, 1949, Grand Central Palace, New York, N. Y.

Institute of Radio Engineers. Second Southwestern Conference. December 9–10, 1949, Baker Hotel, Dallas, Tex.

International Scientific Radio Union–Institute of Radio Engineers. October 31–November 2, 1949, National Academy of Sciences and New State Department Building, Washington, D. C.

Iowa Utilities Association Management Conference. October 10–11, 1949, Hotel Fort Des Moines, Des Moines, Iowa.

National Conference on Industrial Hydraulics. Fifth Annual Meeting. October 26–27, 1949, Sheraton Hotel, Chicago, Ill.

National Council of State Boards of Engineering Examiners. 28th Annual Meeting. November 10–12, 1949, Sheraton Plaza Hotel, Daytona Beach, Fla.

National Electrical Contractors Association. Annual Convention. November 7–10, 1949, Rice Hotel, Houston, Tex.

National Electrical Manufacturers Association. November 14–18, 1949, Chalfonte-Haddon Hall, Atlantic City, N. J.

National Safety Congress and Exposition. October 24–28, 1949, Stevens, Congress, and Morrison Hotels, Chicago, Ill.

Pacific Industrial Conferences-Pacific Chemical Exposition. November 1–5, 1949, San Francisco Civic Auditorium, San Francisco, Calif.

Petroleum Electric Power Association. Annual Conference. November 17–18, 1949, Hotel Beaumont, Beaumont, Tex.

Radio Manufacturers Association-Institute of Radio Engineers. 1949 Radio Fall Meeting. October 31–November 2, Hotel Syracuse, Syracuse, N. Y.

Society of Automotive Engineers. Aeronautic Meeting and Aircraft Display. October 5–8, 1949, Biltmore Hotel, Los Angeles, Calif.

Society of Motion Picture Engineers. 66th Semiannual Convention. October 10–14, 1949, Hollywood-Roosevelt Hotel, Hollywood, Calif.

"Reel Tension Sled" Strings Power Lines

Shown above is the patented "reel tension sled," developed by Stemm Brothers, Inc., Leavenworth, Wash. The sled permits heavy reels of power cable to be handled and unspooled under exact control. In operation, a single reel tender can regulate the tension on all seven lines simultaneously during the stringing of a double-circuit system. The 3-reel sled partially conceals a smaller unit, which handles the static line

URSI-IRE Fall Meeting. The regular fall meeting of the International Scientific Radio Union and Institute of Radio Engineers, sponsored jointly by the USA National Committee and the IRE Professional Group on Wave Propagation and Antennas, will be held on October 31, November 1, and 2, 1949, in Washington, D. C. This will be one of the four meetings of the USA National Committee planned prior to the Zurich Assembly of the International Scientific Radio Union in 1951. The USA National Commissions participating in this meeting will be: Tropospheric Radio Propagation; Ionospheric Radio Propagation; Extraterrestrial Radio Noise; and Radio Waves and Circuits, including General Theory and Antennas. Printed programs will be available prior to the meeting. A charge of one dollar will be made for these in lieu of a registration fee. All correspondence regarding details of the meeting should be addressed to the Secretary, Dr. Newbern Smith, Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

American Welding Society Convention. The American Welding Society will hold its 30th Annual Meeting at the Hotel Cleveland, Cleveland, Ohio, October 17–21. As usual, the meeting will be held in conjunction with the National Metal Exposition at the Cleveland Public Auditorium. Three other national technical societies, the American Society for Metals, the American Institute of Mining and Metallurgical Engineers (Metals Division), and the Society for Non-Destructive Testing, will also convene for their annual conventions at the same time. The Welding Society's program includes technical sessions every day, Monday through Friday. A total of 77 technical papers are now scheduled for the 21 technical sessions. Special features are: the awarding of medals and prizes and the Adams Lecture; the President's Reception; and a Business in Welding forum. The Educational Lecture Series will be given again with lectures scheduled for Monday, Tuesday, and Wednesday afternoons. An informal get-together and registration will be held for those who arrive at Cleveland on Sunday, October 16.

Minnesota Builds Proton Accelerator. Construction of a 50-million-volt proton linear accelerator, which will be the world's most powerful atom smasher of its type, will be started at the University of Minnesota this year under a $728,000 grant from the Atomic Energy Commission. Under the terms of the agreement between the Atomic Energy Commission and the university, the initial grant of $728,000 covering a 5-year period, is intended to finance the development, design, building, and initial operation of the atom smasher. Although a site for the accelerator has not yet been selected, a team of university physicists and electrical engineers, headed by Dr. John H. Williams, physics professor, as project director, are already hard at work on preliminary plans for the machine. Purely a research device with no direct connection with the production of atomic bombs, the machine will accelerate hydrogen ions to a speed of 60,000 miles per second. Ions thus speeded up will be used to disintegrate and interact with nuclei of other atoms in an attempt to understand the forces which hold these nuclei together.

Pacific Industrial Conferences. World Trade will be featured at the Pacific Industrial Conferences, which run concurrently with the Pacific Chemical Exposition at the San Francisco Civic Auditorium, November 1–5, 1949. The program will be split in to two divisions. One group of speakers will cover subjects slanted to the executives of those companies who have had no experience in the export or import business, but who wish to expand their sales by entering it. The other group will cover subjects which will concern current problems of trade with Pacific Basin countries. Speakers will be selected who have had successful careers in the field of exporting and importing.

RMA-IRE Radio Fall Meeting. The latest developments in radio and television engineering and manufacturing are to be discussed at the annual Radio Fall Meeting of members of the RMA Engineering Department and the Institute of Radio Engineers, October 31–November 2 at the Hotel Syracuse, Syracuse, N. Y. The 3-day session will feature both morning and afternoon technical meetings on industry developments and the annual stag dinner the evening of November 1. Leslie J. Woods, Vice-President of the Philco Corporation, will serve as toastmaster and Kenneth W. Jarvis will speak on "The Engineering Aspects of Sin."

Bacon Heads Chicago Technical Group. R. H. Bacon has been elected President of the Chicago Technical Societies Council for 1949–50. He is Vice-President of the industrial advertising agency of Kreicker and Meloan, Inc., and President of R. H. Bacon and Company, business paper editorial service. For the past 25 years he was been active in engineering society work in Chicago having been Chairman of the Chicago Section of the American Society of Mechanical Engineers in 1928 and President of the Chicago Engineers Club in 1947.

Millikan and Darwin Named to RDB. Dr. Clark B. Millikan has been named Chairman and Fred A. Darwin, Executive Director, of the Research and Development Board's Committee on Guided Missiles. Dr. Millikan, Acting Director of the Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, who has been a member of the committee since its formation, succeeds Dr. Frederick L. Hovde, president of Purdue University, Lafayette, Ind. Dr. Millikan is a Lieutenant Commander in the United States Naval Reserve, which he joined in 1934. Mr. Darwin, who will direct the activities of the Committee Secretariat, has been with the Hazeltine Electronics Corporation, Little Neck, N. Y., since 1946.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Ampere Museum

To the Editor:

The Société des Amis d'André-Marie Ampere wishes to extend to members of the AIEE an invitation to visit the Ampere Society and Museum at Poleymieux, a few miles from the city of Lyons, France, any time they may be in the region.

It is a worthy pilgrimage, in which one may gather the spirit of the man who founded the science of electrodynamics. The instruments, papers, and other souvenirs of the great physicist and mathematician may be seen at the charming spot, at one time his home, which has been turned into a museum through the generosity of two Americans.

Any one may join in the work of the society and become a member for as little as $1 a year. The funds are used to maintain the shrine at Poleymieux and, when they so permit, to help worthy young electrical engineers. Further information may be obtained from the society's American delegate, David Landau, Engineer, 353 Fort Washington Avenue, New York 33, N. Y. (telephone WA 8-0584).

L. DOMENACH

(Délegué Général, Societe des Amis d'Andre-Marie Ampère, Lyon, France)

Determination of Turn Ratio

To the Editor:

It is sometimes desirable to consider an engineering problem in a strictly theoretical way with the actual conditions idealized or simplified as much as possible. The determination of the turn ratio of a transformer is such a problem.

Assume that a transformer has 100 turns in the primary winding and 99 turns in the secondary winding. The exact ratio of turns is 100 to 99, and the only way in which this ratio can be determined is by counting

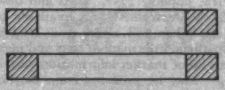

Figure 1

the number of turns in the windings. It is easily shown that there are no electrical measurements, even if made with absolute precision, by which this ratio, 100 to 99, can be determined exactly.

Consider a transformer which has equal primary and secondary windings arranged as in Figure 1. Assume that there is no magnetic core so that the disturbing factors of magnetic saturation and hysteresis are absent.

The primary and secondary coils each have a resistance r and a self-inductance L, and the mutual inductance is M. Neglect electrostatic capcitance and assume that circuit theory applies. These constants r, L, M, completely determine the operation of this transformer and any other transformer which

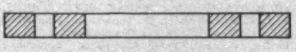

Figure 2

has the same constants cannot be differentiated from it. Now consider a second transformer with the coils arranged as in Figure 2. The inner coil is identical with the coils in Figure 1. The outer coil has the same resistance r and the same self-inductance L as the inner coil, but because of its greater diameter it has fewer turns. The mutual inductances between the coils in Figure 1 and in Figure 2 can be made equal by adjusting the distance between the coils in Figure 1. Therefore the coils in Figure 1 and in Figure 2 have the same constants and cannot be differentiated although their turn ratios are not equal. Consequently, it is theoretically impossible to measure the exact turn ratio of a transformer. Any estimation of the turn ratio based on electrical measurements must depend in part upon assumptions which should be specified.

WALDO V. LYON (F '33)

(Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.)

Use of "Ohmic"

To the Editor:

The word "ohmic," I suggest, is one which electrical engineers should drop from their vocabulary. It is a word which has been strained to unnatural uses and has consequently lost any precise meaning so necessary in engineering.

The legitimate and natural meaning of "ohmic" is given by Webster, "of or pertaining to an ohm; measured in ohms." Various things are measured in ohms—resistance, reactance, impedance—just as various liquids are measured in gallons. Perhaps the fact that resistance was an earlier concept than reactance and impedance accounts for a more restricted meaning of "ohmic" in the terms "ohmic drop" and "ohmic loss," as defined by Roget (1943), but in the present day this narrow use of "ohmic" is unnatural and misleading.

The term "ohmic resistance" seems to have a similar background, but has even greater drawbacks. If it meant only resistance measured in ohms" that would be natural and legitimate, but it has been defined and used in various restricted senses so that now a reader encountering this term can only guess at its intended meaning. The writer has browsed through various dictionaries, glossaries and standards, British and American, dated from 1902 to 1943, and has found various definitions. Most are equivalent to "d-c resistance" as in ASA Standard *C42*, but Hobart (London, 1910) gives a broader definition which includes what we call "effective resistance." That confusion still exists is shown by a comparison of Webster's (1934) definitions of "impedance," "resistance," and "ohmic resistance."

Finally we come to the term "ohmic impedance," which I have never seen before it appeared in the interesting electrical essay "The Steinmetz Network" (*EE, Jul '49, p 614*). Probably the writer is making a perfectly proper use of "ohmic" to mean only "measured in ohms," but after all the uses and misuses of the word as cited, who can be sure?

The AIEE has done well to avoid, in its definitions and in most of its literature, the word "ohmic," which, in view of its associations and irrational uses, has become a positive detriment to clear understanding of a writer's meaning. Let us therefore discourage the use of "ohmic" and stick to our own adopted terms defined in Standard *C42*.

C. KENT DUFF (M '41)

(Hydro-Electric Power Commission of Ontario, Toronto, Ontario, Canada)

Polar Vector Indicator

To the Editor:

The brief article "Polar Vector Indicator," (*EE, Jun '49, p 489*) was of particular interest, as I recently developed a circuit which permits display of voltage vectors on a standard cathode-ray oscilloscope, and has proved very helpful in introducing to students the vector representation of alternating quantities. For this purpose the full vector line is preferable to a spot at the tip of the vector.

Two quadrature voltages are obtained from a series connection of a resistor with either an inductor or a capacitor. To show these voltages as vectors, the RI drop and XI drop are separately phase-shifted to a phase difference of 180 degrees, rectified and applied to the horizontal and vertical amplifiers of the oscilloscope. Reversing switches permit proper polarization so that the RI voltage draws a horizontal line to the right from the screen center alternately with the XI line vertically upward or downward from the same origin. The eye, of course, blends the consecutively-drawn lines into a single picture. To show the resultant of these two voltages a switch is thrown, reversing the phase shift to bring the RI and XI voltages into exact phase. The electron beam is thus moved simultaneously in the horizontal and vertical directions, tracing a single line which is the true vector sum of the components.

G. H. LYLE (A' 38)

(Instructor in Vocational Electrical Mechanics, J. Sterling Morton High School and Junior College, Cicero, Ill.)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

INSTALLATION AND SERVICING OF LOW-POWER PUBLIC ADDRESS SYSTEMS. By J. F. Rider, Publisher, 480 Canal St., New York, N. Y., 1948. 208 pages, illustrations, diagrams, charts, tables, 7¾ by 5½ inches, cloth, $1.89. Stressing practical facts and ideas, this book deals with the installation and servicing of low-power public address systems. The fundamentals of sound and pertinent acoustical problems, an explanation of devices used as inputs to an amplifier, various types of audio amplifiers, and the subject of impedance matching are included.

INTRODUCTION TO COMPLEX VARIABLES AND APPLICATIONS. By R. V. Churchill. McGraw-Hill Book Company, New York, N. Y., Toronto, Ontario, Canada, London, England, 1948. 216 pages, diagrams, tables, 9½ by 6 inches, cloth, $3.50. An introduction to the theory of complex variables is combined with an adequate treatment of applications for the use of students preparing to enter the fields of physics, theoretical engineering, and mathematics. The part of the theory most needed in these fields is treated carefully and is accompanied by examples and exercises.

KINEMATICS OF MACHINES. By A. F. MacConochie. Pitman Publishing Corporation, New York, N. Y., and London, England, 1948. 217 pages, illustrations, diagrams, 9½ by 6 inches, cloth, $3. Based on a course presented at the University of Virginia, this book is designed to meet the needs of second- and third-year students of engineering. A knowledge of elementary mechanics and mathematics is assumed. Following a review of several simple, early machines is a consideration of the elements of mechanism. Geometry, velocity, and acceleration are considered in their relationship to mechanism. The last section deals directly with the kinematics of simple machine elements.

MATHEMATICAL BASIS OF THE ARTS. By J. Schillinger. Philosophical Library, 15 East 40 Street, New York, N. Y., 1948. 696 pages, illustrations, diagrams, charts, tables, 9½ by 6½ inches, cloth, $12. This book demonstrates how creative works may be synthesized through mathematics. Painting, music, and industrial design are important topics considered. The original method of rhythmic design should prove a fertile source of fresh techniques. This integration of science and art is one which has been sought by esthetic philosophers since the time of Leonardo da Vinci.

TECHNICAL DRAWING PROBLEMS, series 2. By H. C. Spencer, and H. E. Grant. Macmillan Company, New York, N. Y., 1948. No pagination, illustration, diagrams, charts, tables, 11 by 9½ inches paper, $4.25. Using for the most part completion-type problems, this work book presents a wide variety selected from current industrial practice. A "work plan" section contains specific instructions for solving all the problems given, together with references to the companion text: "Technical Drawing," by Giesecke, Mitchell, and Spencer, the second edition, 1940. Technical lettering and freehand technical sketching are covered, as well as the customary drawing-board work.

TECHNICAL WRITING. By K. Hendricks and L. A. Stockdart. Utah State Agricultural College, Logan, Utah, 1948. 117 pages, diagrams, charts, maps, tables, 9¼ by 6 inches, cloth, $1.50. Designed as a text for the student in technical writing and as a quick reference manual for the experienced research worker. Every phase of research writing with the exception of sentence and paragraph construction is included. Emphasis is placed upon the gathering of material, the collecting of data, and the handling of illustrations, foot notes, and cross references. Methods of exploring a field and recording the findings are considered.

MEASUREMENT OF STRESS AND STRAIN IN SOLIDS (Physics in Industry). Institute of Physics, 47 Belgrave Square, London, S. W. 1, England, 1948. 114 pages, illustrations, diagrams, charts, tables, 9½ by 6 inches, linen, 17s.6d. plus 10d. postage; United States, $4. Based on the "Proceedings" of a conference arranged by the Institute of Physics and held during July 1946. Three papers survey the fields of electrical resistance strain gauges, recent developments in photoelasticity, and methods for measurement of strain, such as extensometers and the use of brittle lacquer coatings. The other papers are concerned with the details of the applications of various techniques to specific problems.

MICROWAVES AND RADAR ELECTRONICS. By E. C. Pollard and J. M. Sturtevant. John Wiley and Sons, New York, N. Y.; Chapman and Hall, Ltd., London, England, 1948. 426 pages, illustrations, diagrams, charts, tables, 9½ by 5½ inches, linen, $5. In this book, a physicist and chemist have presented the postwar developments and the peacetime applications of radar. After surveying the field, the special knowledge of electricity and magnetism necessary to an understanding of microwaves is outlined. Discussed in detail are the significance of microwave and radar electronic techniques in physical and chemical research. Much attention is devoted to the applications considered in scientific literature since the end of the war.

MOTION AND TIME STUDY. By R. M. Barnes. Third edition. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1949. 559 pages, illustrations, diagrams, charts, tables, 9½ by 6 inches, cloth, $5. This standard text presents the basic principles that underlie the successful use of motion and time study supplementing each with illustrations and practical examples. Five new chapters deal with process analysis, gang process charts, activity charts, and man and machine charts. There is new material on rating operator performance and motion and time study training programs.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

The Nitrogen Meter, PB 95882. Describes a device for continuously recording the concentration of nitrogen in gas mixtures by photoelectric means. Available at $5 in photostat and $2.25 in microfilm from the Librarian of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C.

Human Factors in Safety. A series of six sound slide films, 35 millimeter, 33⅓ rpm, intended as a visual training course for foremen. Films deal with production and job attitudes, as well as safety. For further information, write the National Safety Council, 20 North Wacker Drive, Chicago 6, Ill.

The Royal Institute of Technology (KTH), Stockholm, PB 95881. A 77-page booklet describing the Royal Institute's organization, staff, laboratories, and current research work. Priced at $10 in photostat, $3.50 in microfilm. Send orders to Librarian of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C.

Aluminum Alloy Castings. A 64-page booklet covering the characteristics, production, and application of aluminum alloy sand and permanent-mold castings. May be obtained at 50 cents per copy from the Aluminum Association, 420 Lexington Avenue, New York 17, N. Y.

Calculating Deflection of Curved Beams. A 7-page leaflet discussing problems of flexural deflection and presenting methods for their solution. Requests should be addressed to Librarian, The Cooper Union Library, Cooper Square, New York 3, N. Y.

Technion Yearbook, 1948. A publication of the American Society for the Advancement of the Hebrew Institute of Technology in Haifa, Palestine. Contains articles on Israel's resources and potentialities, science and technology in general, and describes activities of the society. For more information, write the American Technion Society, 154 Nassau Street, New York 7, N. Y.

Careers in Engineering and Science. Intended to help high school students and guidance counsellors, the pamphlet describes the prerequisites for studying engineering and science, and the actual experience the student will have in school while preparing for his profession. Available on request from Committee on Admissions, Polytechnic Institute of Brooklyn, 85 Livingston Street, Brooklyn, N. Y.

Statistics of Publicly Owned Utilities. Presents financial and operating data on publicly owned utilities having annual electric operating revenues in excess of $250,000. Copies of the report, at $1 each, may be obtained from the Publications Division, Federal Power Commission, 1800 Pennsylvania Avenue N. W., Washington 25, D. C. The order number is FPC-S-67.

Standard Samples Issued or in Preparation by the National Bureau of Standards. NBS Circular 398. Contains a schedule of weights and fees, and directions for ordering. Available from the National Bureau of Standards, United States Department of Commerce, Washington, D. C.

Publications, United States Employment Service, January 1949. Lists and describes publications of the USES available to the public. They fall under the headings of occupational information, tests and measurements, labor market information, and counseling. May be procured from the Federal Security Agency, Social Security Administration, Washington 25, D. C.

Tables of Scattering Functions for Spherical Particles. Applied Mathematics Series 4. Contains numerical data computed from Mie's equations. Scattering functions for real and complex indexes of refraction are given. Priced at 45 cents. Superintendent of Documents, United States Government Printing Office, Washington 25, D. C.

Testimonial for free enterprise

WE started in a blacksmith shop 90 years ago. One of our first jobs in supplying wire was for a fellow named Morse who invented the telegraph. Mr. Morse became one of our very good customers. He also brought us one of our first problems in cable manufacture, and that was finding a good insulating material that would withstand heat and cold, light, wind, weather, water, etc.

Mr. A. G. Day solved the problem with an invention called Kerite—an ingredient which is responsible for the remarkable performance of Kerite insulation. Some early Kerite cable—made nearly 70 years ago—is still in first-class condition.

Kerite made to the old formula is still used in our insulation. That is what makes Kerite insulation such a good buy today—it gives long service at a low cost per year.

The Kerite Company grew out of a need—and has continued growing because it continues to fill a need. That is the way our Free Enterprise system works.

We think Kerite is a good testimonial to American Free Enterprise. And we will constantly endeavor to merit the continued confidence of the people we have served under that system during the last 90 years. The Kerite Company, 30 Church Street, New York 7, N. Y.

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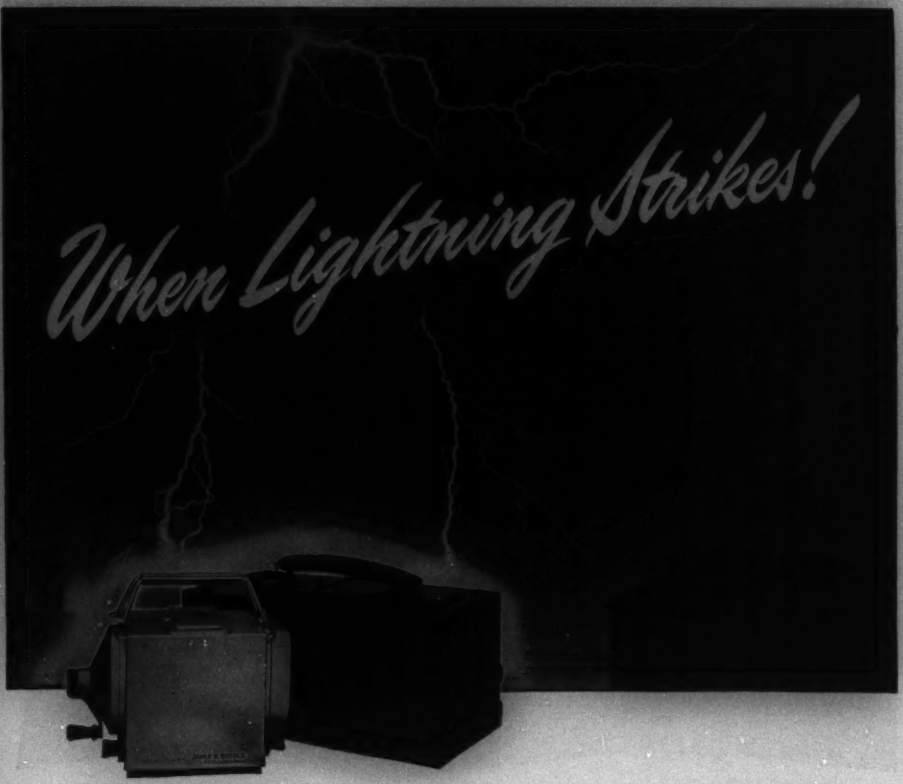

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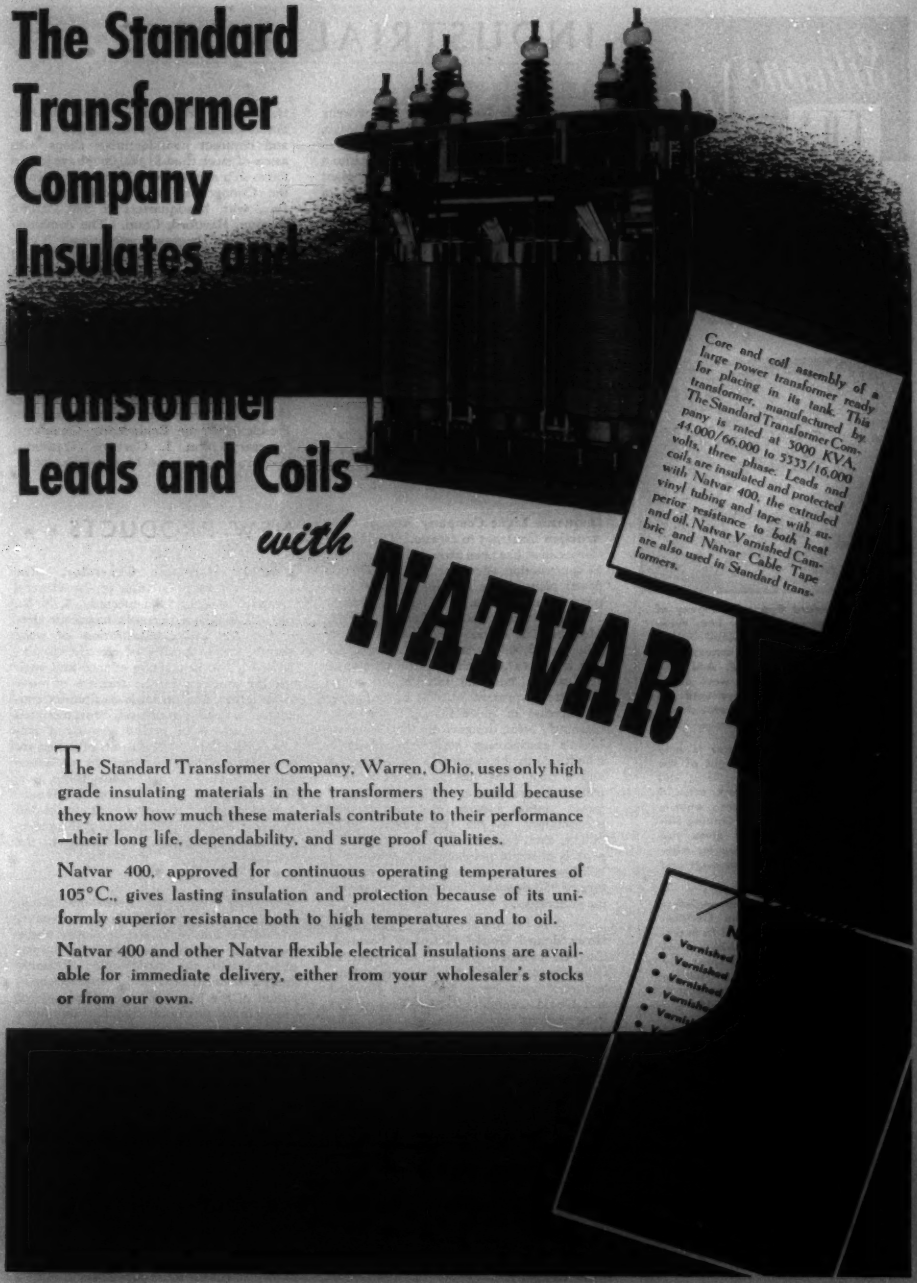
1316 ARCH STREET PHILADELPHIA 7, PA

The Standard Transformer Company Insulates and Transformer Leads and Coils *with* NATVAR



Core and coil assembly of a large power transformer ready for placing in its tank. This transformer, manufactured by The Standard Transformer Company is rated at 5000 KVA. 44,000/66,000 to 5333/16,000 volts, three phase. Leads and coils are insulated and protected with Natvar 400, the extruded vinyl tubing and tape with superior resistance to both heat and oil. Natvar Varnished Cambric and Natvar Cable Tape are also used in Standard transformers.

The Standard Transformer Company, Warren, Ohio, uses only high grade insulating materials in the transformers they build because they know how much these materials contribute to their performance —their long life, dependability, and surge proof qualities.

Natvar 400, approved for continuous operating temperatures of 105°C., gives lasting insulation and protection because of its uniformly superior resistance both to high temperatures and to oil.

Natvar 400 and other Natvar flexible electrical insulations are available for immediate delivery, either from your wholesaler's stocks or from our own.

Silicone News

DC SILICONES

Here's where DC Silicone Insulation Saved $700 per hour

It cost Standard Gypsum Company of California about $700 per hour every time heavy overloads caused the 25 h.p. motor driving screw conveyors in the mixing house to fail. And such expensive motor failures were occurring every 30 to 60 days until the silicone insulated 10 h.p. motor shown above was installed in December, 1948.

This silicone insulated motor is only about ½ the size and weight of the motor formerly used, yet, it is still performing the same work after 8 months without failure. That's what is meant when we say Dow Corning Silicone Electrical Insulation gives you more power per pound, greater reliability, reduced maintenance costs and increased production.

Every day, more and more engineers are specifying DC Silicone Electrical Insulation in motors exposed to excessive heat, moisture, or heavy overloads. If you would like to learn why these engineers are relying on Silicone Insulation, phone our nearest branch office or write for booklet M-10

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Atlanta • Chicago • Cleveland • Dallas
Los Angeles • New York
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Photo courtesy Standard Gypsum Company of California

FIRST in Silicones
Dow Corning

INDUSTRIAL NOTES ....

Soreng Builds New Plant. The Soreng Manufacturing Corporation, of Chicago, Ill., will celebrate the 25th anniversary of its existence, in October, by moving into a completely new, modern one-story plant in Schiller Park, a Western suburb of Chicago. The plant has an area of approximately 60,000 feet, and is almost self-contained from raw products to finished assemblies.

National Electronics Purchases Liquid Carbonic Equipment. National Electronics, Inc., Geneva, Ill., has purchased the high-capacity resistance welding equipment formerly used by Liquid Carbonic Corporation, at Morrison, Ill., in the production of refrigerators. (The Liquid Carbonic factory building was sold earlier this year to General Electric). This equipment is being installed at National's new plant in Geneva, and will be used in the production of industrial rectifier, thyratron, and mercury pool tubes.

Duquesne Light Company Assigns Construction Contract to Dravo. The Dravo Corporation has been awarded the contract as construction agent for the $28,000,000 power plant of the Duquesne Light Company, Pittsburgh, Pa., to be built at Elrama, Pa., four miles above Clairton on the Monongahela river. The plant will contain two 95,000-kw steam turbine generators, largest to be specified for the Duquesne light system, and will add 190,000 kw to the system's present 802,000 kw capacity, an increase of more than 23 per cent. Currently being designed by the Duquesne Light's engineering staff, the plant is scheduled to be under construction by Dravo early next year; completion date will be about mid-year 1952. Plans for the power station include electrostatic dust precipitators on the two boilers. The boilers, each capable of supplying 900,000 pounds of steam per hour at a pressure of 1,250 pounds per square inch at a temperature of 950 degrees Fahrenheit, will power the generators.

Howard and Gould Company Formed. Carl G. Howard (M '36), and John P. Gould have consolidated their own manufacturers' agencies to form the Howard and Gould Company, with offices at 105 West Adams Street, Chicago, Ill. The new company will represent several manufacturers of electrical and electro-mechanical products in the railway, utility, communication, and industrial fields throughout the central west, formerly represented individually by the two partners.

Pioneer Service and Engineering Election. George W. Knourek, formerly Vice-President and Treasurer of Standard Gas and Electric Company, has joined the staff of Pioneer Service and Engineering Company, Chicago, Ill., as Vice-President and Director. Mr. Knourek will be in charge of the Department of Finance and Accounts of the company.

Connecticut Mechanical Firms Merge. Seven well-known Connecticut tool and die and contract manufacturing shops with assets of more than $1,000,000, have joined forces in a new corporation to be known as the Connecticut Mechanical Industries, Inc., with headquarters at 390 Capitol Avenue, Hartford, Conn. The combined resources of the new corporation will give a lift to the sharp business decline small tool and die firms have experienced since the end of the war, and companies will not have to go outside Connecticut to find tool and die firms able to handle the larger contracts. Officers of the corporation are as follows: President, John H. Dowd, President of the Johns-Hartford Tool Company; Vice-President, Herman Fink, President, Cooperative Tool and Machine Company; Treasurer, Charles Neumann, President, Argus Engineering Company; Secretary John I. Carlson, Treasurer, Cooperative Tool and Machine Company.

NEW PRODUCTS ..

Portable Harmonic Generator. The Special Products Division of the General Electric Company, Schenectady, 5, N. Y., has developed a portable harmonic generator, for the demonstration of wave shapes and properties of electric circuits, to be used in instructing science and engineering students in the theories of wave formation. The portable equipment consists of six voltage-generating units mounted on a single shaft and driven by a synchronous motor. The outputs obtained are a fundamental voltage and five harmonic voltages having frequencies two, three, four, five, and seven times that of the fundamental voltage. Range is from zero to 360 degrees. Further information of the generator may be obtained by writing to the company.

Ultrasonic Analyzer. Panoramic Radio Products, Inc., 10 South Second Avenue, Mount Vernon, N. Y., has developed a new panoramic system, available in an instrument called the panoramic ultrasonic analyzer, Model *SB-7*, which enables observation of the frequency and amplitude of one or many ultrasonic signals at one time. Indications are obtainable for signals between 2 kc and 300 kc in the form of vertical deflections distributed across a cathode-ray tube screen, calibrated horizontally in frequency and vertically in amplitude to provide direct readings of these values. Other characteristics are a continuously variable scanning width from a 200-kc maximum to zero; full scale deflections for input voltages between 1 millivolt and 50 volts; signal amplitude ratios as high as 300 to 1 are measurable; a linear and 2-decade log amplitude scale; and a continuously variable resolution, enabling analysis of signals separated by as

(*Continued on page 22A*)

Jack of ONE trade

—and MASTER of it!

CORNELL-DUBILIER

THE POWER-FACTOR CAPACITOR SPECIALIST FOR UTILITIES

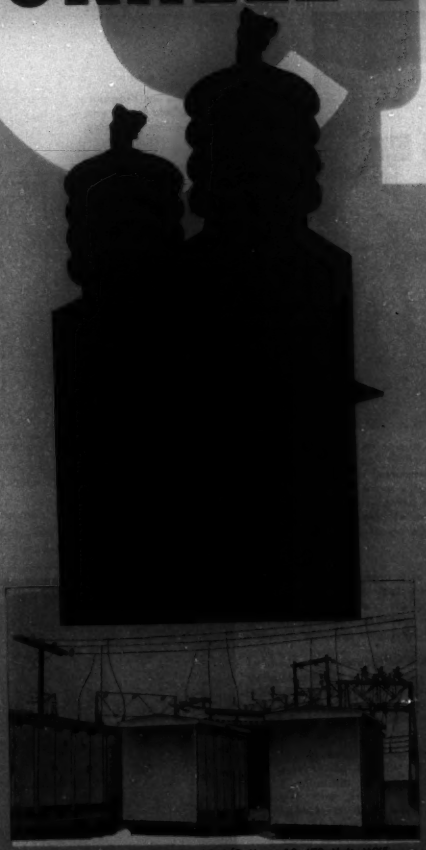


Photo showing section of a 37,680 Kvar, 12,470 Volt, WYE, isolated neutral, station-type C-D capacitor installation.

More than a decade ago, C-D installed its first power-factor capacitor installation. It's given trouble-free service ever since. During the intervening years C-D capacitors have rolled up a record of better than 10-years average service on utility systems and in manufacturing plants throughout the world. Specialization has enabled us to produce a better power-factor capacitor.

Our engineers will be glad to discuss with you the advisability of a capacitor designed for your specific needs. Your inquiry is cordially welcomed. Cornell-Dubilier Electric Corporation, Dept. B109, So. Plainfield, New Jersey. Other plants in New Bedford, Worcester, Brookline, Mass.; Providence, R. I.; Indianapolis, Ind. and Cleveland, O.

Follow the leaders

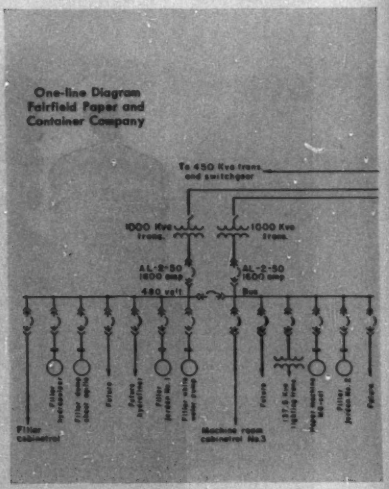
Demand dependable C-D Capacitors —built by capacitor specialists.

C-D Best by Field Test!

FAIRFIELD
PAPER AND CONTAINER CO. chooses a

METAL-CLAD
for

General Electric 5-kv Type MI-6 metal-clad switchgear consisting of one incoming-line breaker and four feeder breakers to handle 4160 volts at Fairfield Paper and Container Co. Magne-blast air circuit breakers are rated 1200 amperes, 100,000 kva interrupting rating. Note neat appearance of metal-clad unit. It's space saving too, and the metal-clad construction offers operating safety to personnel. Units like this are easily installed and can be added to with a minimum of bother and expense. Instruments and relays are co-ordinated for positive protection of circuits.



G-E Cabinetrol units provide centralized control for the liner stock system. Unit controls motors, valves, agitators, etc. Ammeters record load carried by hydrapulper and hydrofiner. Four other Cabinetrol units are used throughout the mill.

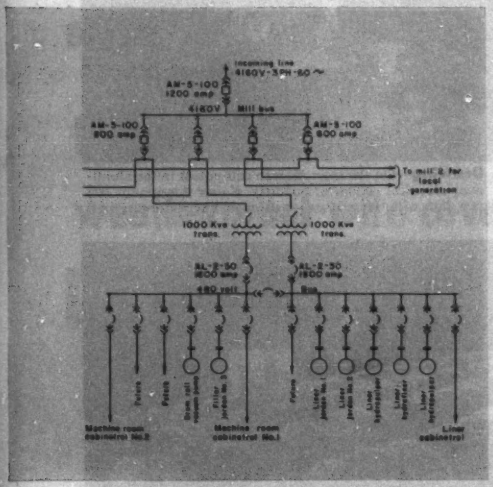
The Fairfield installation is a complete General Electric project—one source of responsibility plus the very best in co-ordinated planning, engineering, manufacturing, and servicing facilities to give maximum savings and efficiency to the customer.

Two G-E low-voltage metal-enclosed switchgear equipments take the 480-volt power from the 1000-kva transformers and distribute it to motors, lighting transformers, and five Cabinetrol units. The Type AL-2 transformer secondary breakers and tie breakers are rated 1600 amperes, 50,000 amperes interrupting rating. Type AK-1 drawout air circuit breakers of 25,000 ampere interrupting rating are used to feed motors and Cabinetrol. Breakers for future circuits can be installed in spare compartments. G-E air circuit breakers have adequate "IC" (Interrupting Capacity) for short circuit protection, are easily removed for inspection.

secondary-selective system using

SWITCHGEAR

continuity of service



At the new Fairfield Paper and Container Co. installation General Electric metal-clad switchgear receives the incoming 4160-volt power and distributes it to 4-1000 kva transformers for step-down to 480 volts. G-E metal-enclosed switchgear handles the 480-volt power through air circuit breakers of the drawout type. In general, all motors rated 60 hp and above are served by an individual breaker. Five Cabinetrol units are fed by air circuit breakers. Note that costly secondary feeders are short.

This secondary-selective system is only slightly higher in cost than a simple radial system, and provides Fairfield insurance against a complete shutdown in case of failure of any one transformer or its primary feeder cable. If trouble occurs the normally-open tie breaker is closed, thus providing an alternate source of power which permits the mill to operate at slightly reduced capacity.

Be sure to see the "More Power to America" full-color sound slidefilm "Modern Industrial Power Distribution." Ask your G-E sales representative to arrange a showing for your organization.

here's why...

"When we planned our new facilities it was decided that a secondary-selective power distribution system would assure us of the continuous power, even in case of a major fault, needed for continuous-process operations like ours. We ordered G-E switchgear because their "metal-clad" protection safeguarded our employees, and because we could get all engineering, equipment and service from one organization. By dealing with one company we saved considerable time and money. The units arrived complete and we installed them in very little time."

H. L. CUSTER, VICE PRESIDENT AND GENERAL MANAGER, THE FAIRFIELD PAPER AND CONTAINER CO., BALTIMORE, OHIO

MODERN INDUSTRIAL power distribution systems using G-E switchgear are applicable to any industrial plant or commercial building where you want proper voltage for top performance of equipment, an extremely flexible setup to take care of expanding or changing loads, adequate short circuit protection, safety to personnel, and low installation and maintenance costs. A complete system, using G-E switchgear, costs you less than a "piece-meal," makeshift affair.

INVESTIGATE TODAY the many advantages of using General Electric switchgear in *your* plant for efficient, flexible power distribution. Contact your G-E sales representative for further information—or write for the helpful bulletins listed below. *Apparatus Department, General Electric Co., Schenectady 5, New York.*

GEA-3083	Metal-clad Switchgear
GEA-4966	Low-voltage Metal-enclosed Switchgear
GEA-3592	Load-center Unit Substations
GEA-3758	Load-center Power Distribution
GEA-4057	Interlocked-armor Cable for Primary Circuits
GEA-4352	Flamenol Cable for Secondary Circuits

GENERAL ELECTRIC

Why you can depend on Kaiser Aluminum Conductor

You're sure of dependable supplies of Kaiser Aluminum Conductor—because Permanente Metals' fully integrated production includes all this under one roof at centrally located Newark, Ohio:

1. Rod Rolling—Cast from high purity Kaiser Aluminum pig from Permanente Metals' two reduction plants, ingots pass through breakdown mills to become rods for wire drawing.

2. Drawing—On the most modern equipment in the aluminum electrical conductor industry, Kaiser Aluminum rod is drawn into wire. Here it passes through a series of ten dies.

3. Stranding—Manned by experienced, highly skilled personnel, cable stranders for Kaiser Aluminum electrical conductor spin at high speed. Finished conductor emerges at the left.

4. And the most valuable asset of all: Knowledge of your conductor problems, and the ability to send your shipment of Kaiser Aluminum Conductor out on time.

Do you need aluminum conductor? To take advantage of early delivery schedules, contact any office of Permanente Products' nationwide sales organization.

Permanente Metals

PRODUCER OF

Kaiser Aluminum CONDUCTOR

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BUILDING, OAKLAND 12, CALIFORNIA . . . WITH OFFICES IN:
Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Kansas City
Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Portland, Ore. • Seattle • Spokane • St. Louis • Wichita

Also available through General Electric Supply Corporation, Westinghouse Electric Supply Company, and Line Material Company.

SMALLER DIAMETER—LIGHTER WEIGHT!
SMOOTHER—EASIER TO PULL OVER CROSS-ARMS!
RESISTS DAMAGE FROM FALLING OBJECTS!
NO PLASTICIZER OR OTHER INGREDIENTS TO LEACH OUT!
FITS SNUGLY, BUT EASY TO STRIP CLEAN!
RESISTS MOISTURE, SUNLIGHT, WEATHERING, CORROSIVE ATMOSPHERES, ABRASION!

Look at the features of weatherproof wire covered with DU PONT POLYTHENE!

DU PONT
Plastics
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Write today for data on versatile Du Pont polythene plastic! Easy to mold, extrude and fabricate . . . offers a remarkable combination of properties to the electrical industry. E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Main Sales Offices: Empire State Bldg., New York 1, N. Y.; 7 South Dearborn St., Chicago 3, Ill.; 845 East 60th St., Los Angeles 1, Calif.

Line wire covered with Du Pont polythene made by Anaconda Wire & Cable Co., N. Y. C.; Phelps Dodge Copper Products Corp., Yonkers, N. Y.; Rome Cable Corp., Rome, N. Y.

Here's a Battery Charger that is

Completely Self-Contained

- All components in one cabinet
- No separate units to install
- Cuts installation costs

Starting contactor, voltage and current controls, transformer, filter components, rectifier, meters and protective devices—all components necessary for battery charging and control are contained in the heavy sheet metal cabinet of the PECo Battery Charger . . . Compact design eliminates the necessity of installing separate starter and control panel and the interconnection of power and control circuits . . . AC input and DC output leads may be brought in from the top, simplifying conduit installation . . . There are no moving parts . . . No fans or other ventilating equipment required . . . No special foundations necessary.

Write for full information.

POWER EQUIPMENT *Company*

Specialists in Controlled Rectifiers Since 1935

55 ANTOINETTE STREET / DETROIT 2, MICHIGAN

(*Continued from page 22A*)

little as 500 cycles per second. Further information is available from the company.

Weld Energy Comparator. Westinghouse has announced a new energy comparator, which gives a visual, or audible, or visual and audible signal. The comparator has been designed to check weld energy consistency on applications where high-quality welds are a must, as in the fabrication of high-alloy stainless steel used on jet engines, and is recommended for weld time ranges of 30 cycles and below. Additional information may be obtained from the Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

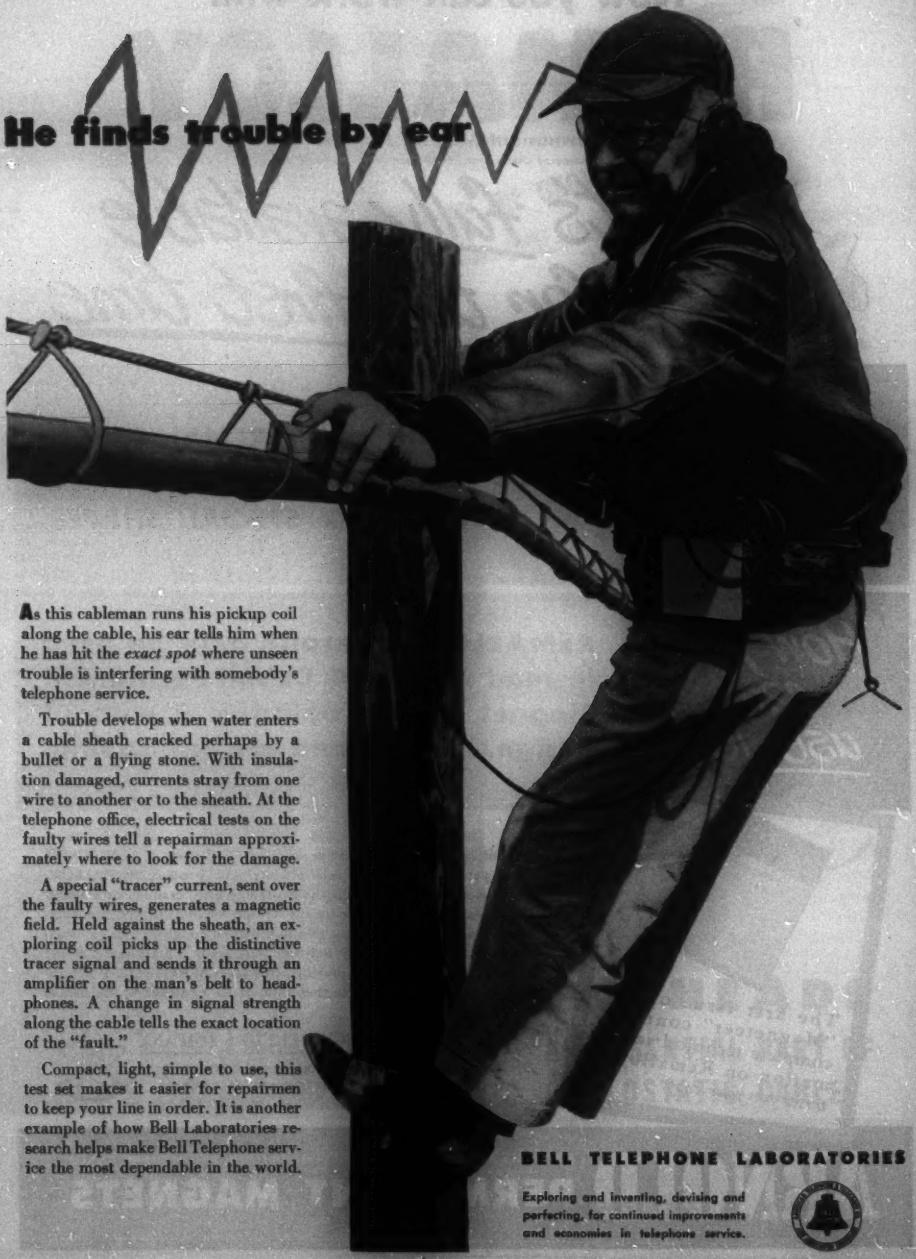
400 Cycle Regulators. Sorensen and Company, Inc., 375 Fairfield Avenue, Stamford, Conn., has developed a group of a-c line electronic voltage regulators and d-c power supplies that will work from a 115-volt a-c, 400-cycle source. The units are compact and light weight, having been specially designed for use in aircraft. Specifications are as follows: input voltage range, 95–215 volts alternating current, 400 to 800 cycles; output voltage, adjustable between 100–120 volts, alternating current; regulation accuracy, 0.5 per cent; power factor range, down to 0.7 power factor. Single-phase a-c regulators are available to 50, 500, 1,200, 2,000, and 2,500 volt-amperes. Additional specifications may be obtained upon request to the company.

Beta Gauge. Tracerlab has announced development of the *SM-3* Beta Gauge, the second of a series of industrial measuring and control instruments using radioactive isotopes. The essential components of the gauge are a source of beta radiation from Strontium-90 and a radiation detector. The sheet material to be measured is interposed between the source and the detector and a part of the radiation is absorbed by the sheet material in proportion to its weight per unit area. Designed for use in small production lines, where initial cost must be kept to a minimum and in processes where manual standardization can be carried out without seriously interfering with production, this instrument will measure the weight per unit area of continuously moving sheets of material up to 700 milligrams per square centimeter, and provide an indication when manufacturing tolerances are exceeded. Further information is available from the manufacturers, Tracerlab, Inc., 130 High Street, Boston 10, Mass.

Impedance Bridge. Brown Electro-Measurement Corporation, 4635 S. E. Hawthorne Boulevard, Portland 15, Oreg., has announced a portable universal impedance bridge, Model *250-A*, which can measure resistance, capacitance, and inductance over the following ranges: resistance, 1 milliohm to 1 megohm; capacitance, 1 micromicrofarad to 100 micro-

(*Continued on page 26A*)

He finds trouble by ear



As this cableman runs his pickup coil along the cable, his ear tells him when he has hit the *exact spot* where unseen trouble is interfering with somebody's telephone service.

Trouble develops when water enters a cable sheath cracked perhaps by a bullet or a flying stone. With insulation damaged, currents stray from one wire to another or to the sheath. At the telephone office, electrical tests on the faulty wires tell a repairman approximately where to look for the damage.

A special "tracer" current, sent over the faulty wires, generates a magnetic field. Held against the sheath, an exploring coil picks up the distinctive tracer signal and sends it through an amplifier on the man's belt to headphones. A change in signal strength along the cable tells the exact location of the "fault."

Compact, light, simple to use, this test set makes it easier for repairmen to keep your line in order. It is another example of how Bell Laboratories research helps make Bell Telephone service the most dependable in the world.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting, for continued improvements and economies in telephone service.

Now you can work with

REMALLOY

Permanent Magnet Material

(Manufactured under license from Western Electric Company)

It's fully available for the first time

How you can get it!

ARNOLD can supply REMALLOY in the form of BARS and CASTINGS or SINTERED TO SPECIAL SHAPES

How you can use it!

REMALLOY generally may be used instead of 36-41% Cobalt Permanent Magnet Steel—replacing it without design changes, and at a cost saving.

The first issue of the "Magneteer" contains complete technical information on Remalloy—*write for your copy.*

In addition to our customary production of all types of ALNICO and other permanent magnet materials, we now produce REMALLOY. The various forms in which it is available—bars, castings or sintered shapes—are all produced under the Arnold methods of 100% quality-control; and can be supplied to you either in rough or semi-finished condition, or as completely finished units ready for assembly. ● Let us help you secure the cost-saving advantages of REMALLOY in your designs. Call or write for further data, or for engineering assistance.

THE ARNOLD ENGINEERING COMPANY

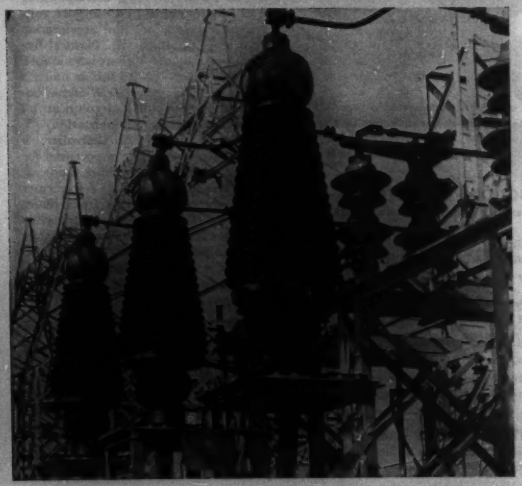
SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

ARNOLD

SPECIALISTS AND LEADERS IN THE DESIGN, ENGINEERING AND MANUFACTURE OF

PERMANENT MAGNETS



Add to the complex requirements of a high voltage bushing, the extra demands imposed by retaining oil at a constant pressure of 200 pounds, and you will appreciate the high degree of specialization involved in O-B Oilostatic Potheads.

Shown here are two installations of these Potheads at opposite ends of a 9.25-mile circuit connecting the Southwark Generating Plant and Westmoreland Substation of Philadelphia Electric Company. Some of the characteristics of this installation are briefly described by the makers of Oilostatic cable, The Okonite Company.... "Voltage, 66 kv, 880 amperes, 105,000 kva rating. Load factor, 90 per cent. Three conductors in single 6¼-inch pipe. Conductor size, 1,500,000 cir mils. Copper temperature, 75 degrees C. Insulation thickness, 0.35-in. And, equipped with..."

POTHEADS

AN ESSENTIAL PART OF OILOSTATIC CABLE

Ohio Brass MANSFIELD, OHIO

(*Continued from page 22A*)

farads; inductance, 1 microhenry to 100 henrys; storage factor $(Q=X/R)$, 0.002 to 1. Frequency of internal generator is 1,000 cycles per second accurate within five per cent, and it is powered by four standard "D" flashlight cells which will give approximately 100 hours of service. Additional specifications concerning the portable impedance bridge may be obtained upon written request to the manufacturer.

Waterproof Electrical Coupling. A quick-disconnect electrical coupling for all-weather and submarine applications is a new development of Roylyn Inc., known as the *1600* Series, the coupling has been designed to meet the rigid requirements of public services and various industries requiring a heavy duty electrical connector that is impervious to moisture and capable of withstanding long periods of complete immersion under high external pressure without leakage. For further details, write to Roylyn Inc., 718 West Wilson Avenue, Glendale 3, Calif.

Heavy-Duty Soldering Gun. The Weller Manufacturing Company, 808 Packer Street, Easton, Pa., has brought out a new model soldering gun capable of handling 250 watts. Designated Model *WD-250*, the new gun is suited to all electrical, telephone, commercial, and industrial soldering. Complete information on the Weller gun is available from the company.

New Calidyne Developments. The Calidyne Company has announced three new products: 1. An electro-dynamic shaker, Model *6*, designed specifically to give a high force output, used for generating oscillatory linear motions or forces in vibration resonance testing, fatigue strength determination and in other applications where large vibratory forces over a wide frequency range are required. Maximum force rating, at any frequency, is 25 pounds; power output at 60 cycles per second is 3/8 horsepower. 2. A Model *18* d-c accelerometer, which allows direct operation of voltage and current sensitive indicators and recorders to higher frequency ranges than before possible without additional amplifying equipment. Pickups having natural frequencies from 80 to 450 cycles per second have a corresponding range of sensitivities from 15 to 0.21 volts per gravity acceleration, and acceleration ranges from 9 to 70 grams. Natural frequencies as high as 1,700 are obtainable. The accelerometers can furnish as much a 400 microamperes into 1,000 ohms impedance or 20 volts into 1 megohm at full range output without amplification. 3. The Calidyne Model *23* Calivolter, a laboratory standard source of potential for use in the calibration of amplifiers, indicating and recording systems, transformer gains and meter sensitivities from direct current to 100,000 cycles per second, when powered by a suitable battery or oscillator. Further information on all of the above instruments is available from The Calidyne Company, 751 Main Street, Winchester, Mass.

Ribbon Solder. The Proved Products Manufacturing Company, Drawer 1190, San Fernando, Calif., has introduced a new type of ribbon solder, a low-melting 3/8-inch flux-containing ribbon which can be applied with heat from an ordinary match or a soldering iron. Additional descriptive literature is available from the company.

Anemotherm Air Meter. The Anemostat Corporation of America has announced development of a new Anemotherm air meter, which is used to measure air velocity from 10 feet per minute to 6,000 feet per

(*Continued on page 34A*)

PHOTOELECTRIC RECORDER

can help solve your problems, too

Here the General Electric photoelectric recorder is being used with an electric tachometer to record minute variations in the speed of a motor under development for the textile industry. It is part of an experiment with a tensiometer aimed at achieving uniform "winding tension" for weaving bobbins. This should lead to greater production and better woven products. The G-E photoelectric recorder is playing a vital part in this development.

EXAMINE YOUR DEVELOPMENT AND PRODUCTION OPERATIONS—then consider the G-E recorder. It can help you solve many problems by supplying accurate, high-speed records of phenomena such as—

Current	Voltage	Temperature	Light	Thickness
Pressure	Strain	Air Flow	Vibration	Speed

Magnetic Flux—or almost any other quantity that can be measured by an indicating instrument.

EXTREMELY SENSITIVE—This versatile instrument comes in two basic forms, a deflection type using a pivoted or suspension-type measurement instrument, and a potentiometer type operating on the null-balance principle. Both types are sensitive far beyond the range of ordinary recording instruments.

HIGH-SPEED RESPONSE—The photoelectric balancing system rapidly moves the recording mechanism to follow exactly the deflection of the measuring instrument or null-balance detector. Yet, it imposes virtually no additional burden on the circuit.

WIDE RANGE OF CHART SPEEDS AND SENSITIVITIES—Chart speeds range from ½ inch per hour to 72 inches per minute. Response speeds can be as fast as ¼ second for full-scale deflection. And sensitivities can be obtained for values as low as 1.0 microampere full scale.

Full details on the other advantages of these instruments, plus operating principles, ratings, prices, etc. are contained in Bulletin GEC-254. Write for your copy today. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

GEA-1561

These coils are designed for continuous operation at

Where standard Class B coils fail with excessive frequency because of high heat, National's special Silicone Mica-Glas coils will reduce the frequency of failure tremendously. They will operate without damage at 356° F., and up to 450° F. under certain conditions. For instance, the life of Class B windings of a motor averaged just 50 days over a four-year period; the same motor in the same work, equipped with National Silicone Mica-Glas windings, has operated for four years without a single failure caused by heat. We can supply such windings for any motor or generator, of foreign or domestic manufacture; they can be installed in our shop or yours, by us or you. If heat-failures cost you money, get in touch with us NOW.

Outside tape: Silicone Fiberglas Tape

Finish: Silicone Varnish Used Exclusively

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

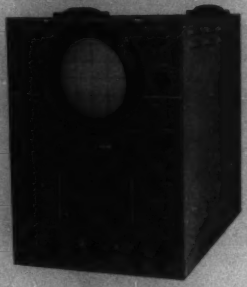
ELECTRICAL ENGINEERS MAKERS OF ELECTRICAL COILS AND INSULATION

REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

Consider the possibilities of this combination of

DU MONT CATHODE-RAY EQUIPMENT

TYPE 250-A CATHODE-RAY OSCILLOGRAPH



● An excellent general-purpose C-R oscillograph designed for observing and recording recurrent and transient phenomena. Amplifies a-c and d-c signals. Linear time-base unusually flexible. Automatic control of beam intensity. Deflection factor through a-c amplifier, 0.015 rms volt/in. max.; through d-c amplifier, 2 d-c volts/in. Recurrent and driven sweeps. Quantitative measurements through built-in calibrator. Type 5CP-A C-R tube for bright traces.

TYPE 263-B HIGH-VOLTAGE POWER SUPPLY

● The Type 250-A may be converted into a high-voltage oscillograph or Type 250-AH which, with addition of this power supply and substitution of Type 5RP-A C-R tube, is capable of displaying writing rates of the order of 40 inches per microsecond. Type 250-AH has, also, such a greater light output (12 times) that it may readily be used as a projection oscillograph.

TYPE 2542 PROJECTION LENS

● With the addition of Type 2542 Projection Lens, the Type 250-AH projects its trace up to 30 feet for a picture size approximately 12 feet square. Advantages of such projections for lecture or demonstration work are readily apparent.

● Lastly, Du Mont Types 271-A and 314-A Oscillograph-record Cameras may be readily mounted on Types 250-A and 250-AH for permanent recording.

● DETAILED LITERATURE ON REQUEST. EQUIPMENT DEMONSTRATED—NO OBLIGATION

DU MONT for Oscillography

INSTRUMENT DIVISION ● 1000 MAIN AVENUE ● CLIFTON, N. J.

American Standard for POOL CATHODE MERCURY-ARC POWER CONVERTERS

Sponsored and published by AIEE, this standard (C34.1–1949), applies to all types of mercury-arc power converters, employing rectifying devices with mercury pool cathodes and used for power conversion purposes, including mercury-arc power rectifiers and inverters, electronic frequency changers and converters used with electronic motors when these equipments employ mercury-arc rectifying devices with pool cathodes. Price: $1.20; 50 per cent discount to members of the AIEE for single copies; Address:

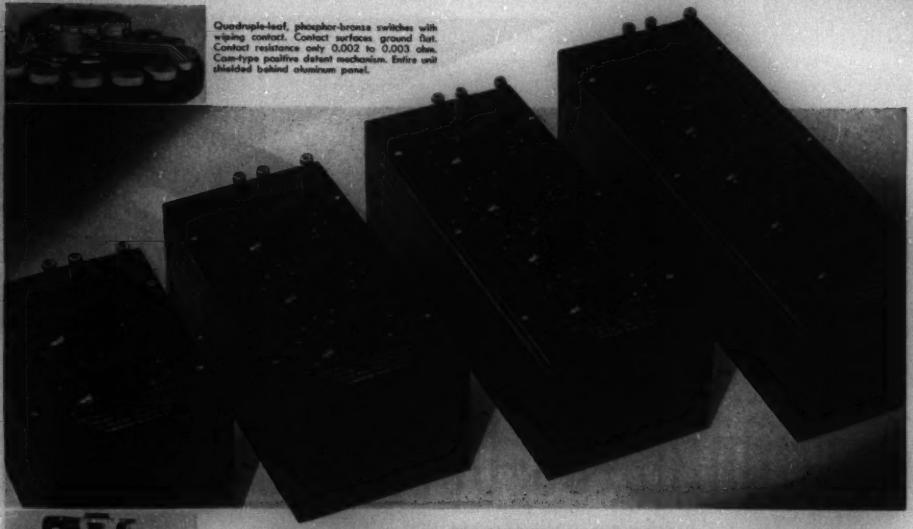
AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

American Standard for TRANSFORMERS, REGULATORS, and REACTORS

This publication (C57–1948) combines, in a single reference work, information relating to the terms and conditions upon which the rating and behavior of transformers and other induction apparatus are based. Data from many sources, notably the established standards of the AIEE and the NEMA, are included. This edition supersedes the American Standard for Transformers, Regulators, and Reactors, C57–1942. Price: $4.00; 50 per cent discount given to AIEE members for single copies. Address:

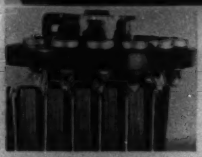
AIEE ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

Quadruple-leaf, phosphor-bronze switches with wiping contact. Contact surfaces ground flat. Contact resistance only 0.002 to 0.003 ohm. Cam-type positive detent mechanism. Entire unit shielded behind aluminum panel.



PRECISION RESISTANCE BOXES

● The General Radio Type 602 Decade Resistance Boxes are universally accepted as the adjustable standard of resistance. Designed primarily for direct-current and audio-frequency use, they can be used as well into the low radio-frequency range.



Aryton-Perry windings on the 1-, 10-, and 100-ohm decades on molded phenolic cards especially shaped and heat treated to minimize aging effects.

Unifilar ribbon windings on the 1,000- and 10,000-ohm decades on mica cards.

Bifilar construction of the 0.1-ohm units.

FEATURES

● **ACCURATE ADJUSTMENT** — all units are adjusted within 0.1% of engraved values, except the 1-ohm cards are within 0.25% and the 0.1-ohm units within 1%.

● **LOW ZERO RESISTANCE** — less than 0.003 ohm per decade

● **LOW TEMPERATURE COEFFICIENT** — less than ±0.002% per deg. C. at room temperatures, except the 0.1-ohm decade is slightly higher

● **LOW RESIDUAL INDUCTANCE AND CAPACITANCE** — in all decades through the 100-ohm steps no serious frequency error below 500 kc

● **THOROUGH AGING** — each resistor aged at temperature of 135 deg. C., reducing subsequent drifting to a negligible amount

● **LOW THERMAL EMF EFFECTS** — through use of manganin, Evanohm or Karma wire

● **SCALE VALUES OVERLAP** — each decade has 11 contact studs and 10 resistance units.

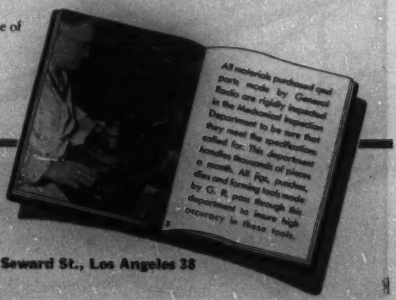
● **POSITIVE DETENT MECHANISM** — switches can be adjusted without looking at panel engraving.

● **ENGRAVED CARRYING CAPACITY** — current ratings of each decade engraved on panel.

● **THOROUGH SHIELDING** — decades mounted on aluminum panel inside copper-lined walnut cabinet

● **EIGHT SIZES** — between 0.1 to 11 ohms (in steps of 0.1 ohm) and 1.0 to 111,110 ohms (in steps of 1.0 ohm)

● **MODERATELY PRICED** — $32.00 to $90.00


All materials purchased and parts made by General Radio are rigidly inspected in the Mechanical Inspection Department to be sure that they meet the specifications called for. The department further thousands of pieces a month. All jigs, fixtures and forming tools made by G. R. pass through this department to insure high accuracy in these tools.

GENERAL RADIO COMPANY

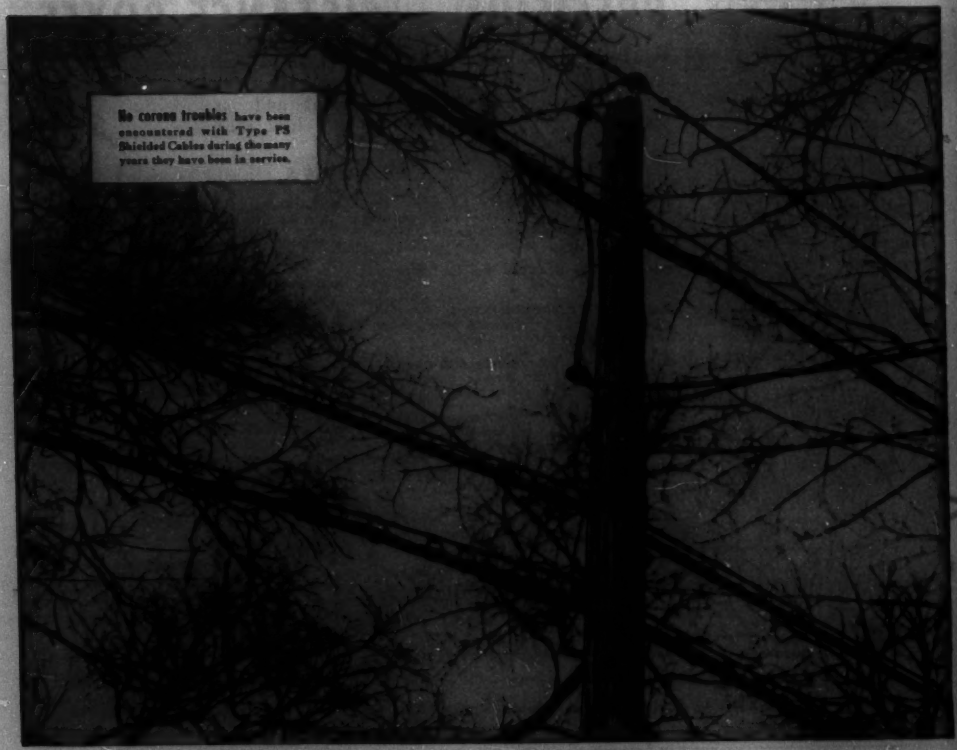
Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

PS SHIELDING

(U. S. Patents 2,322,787 and 2,446,387)

eliminates Corona cutting in



Type PS Shielding is applied to single or multiple conductor cables with rubber, paper or varnished cambric insulation. Sheathing can be rubber or lead to suit the application.

power cables

Low-cost conducting rubber tape proves highly effective

YOU get longer trouble-free life plus elimination of static discharge when Type PS Shielding is used on rubber insulated cables operating at over 2000 V. For rubber cables this low-cost shielding consists of a fibrous tape coated with conducting rubber, vulcanized to the surface of the insulation. Such a tape may be used over the stranded conductor for protection against internal corona and over the outer surface in contact with the usual shielding tape, ground wires or conducting sheath. The tape eliminates any air gaps between insulation and conducting element as it becomes bonded to the insulation during vulcanization.

Type PS Shielding remains flexible . . . is superior to metal shielding which tends to separate slightly from the insulation when the cable is bent and straightened. This forms air gaps . . . causes a spark discharge with corona and ozone formation.

Type PS Shielding with conducting rubber is a development of the American Steel & Wire Company. It proved so successful that other cable companies have been licensed to use the same construction. The main applications are for portable power cable, for aerial distribution lines, and for heavy power cable wherever voltage discharge will cause damaging corona and television interference.

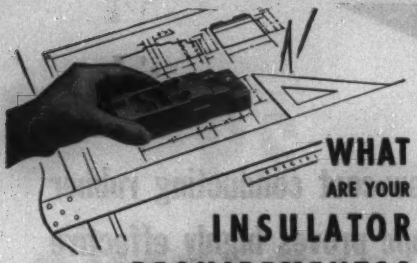
The safety features of the grounded tape make PS Shielded Cable ideal for use in mines and other hazardous locations. PS Shielding has been applied to both single and multiple conductor cables which are sheathed to meet various applications. Write for complete information.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA STEEL COMPANY, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM, SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

American Electrical Wire and Cable

UNITED STATES STEEL



WHAT ARE YOUR INSULATOR REQUIREMENTS?

- ☐ PRECISION MOULDING
- ☐ PHYSICAL STRENGTH
- ☐ HEAT ☐ COLD ☐ MOISTURE ☐ FUMES ☐ ACID
- ☐ DIELECTRIC STRENGTH
- ☐ RESISTANCE TO:

On all of these counts you will find Universal Porcelain Insulators well within your specifications. And to these qualities, inherent in every fine porcelain insulator, Universal adds the experienced engineering and the shop know-how that translates blue prints into production runs of sturdy, long-lived, high-quality, insulators. A Universal engineer will be glad to assist you in developing insulators for your specific needs. No obligation.

THE UNIVERSAL CLAY PRODUCTS CO.
1560 EAST FIRST STREET — SANDUSKY, OHIO

HOW TO MEASURE INSULATION RESISTANCE

VIBROTEST

(Model 201—Range 0-200 Megohms at 500v potential. 150-300-600 volts AC or DC.)

To obtain a proper megohm reading of insulation resistance, it is necessary to provide a constant high voltage DC potential which will produce sufficient current flow through the resistor under test to actuate a means of indication.

VIBROTEST'S EFFORTLESS *Battery-operated* power supply is the *only positive*, "push-button" means of obtaining *constant* high voltage for accurate insulation resistance measurement.

GET BULLETIN 209
Valuable information on insulation resistance measurement. Contains handy reference chart showing proper ranges for general laboratory and field testing; for general industrial testing and for Research testing. WRITE for it, or use inquiry card.

TIRESOME, INACCURATE CRANKING ELIMINATED; No LEVELLING; No ERRONEOUS READINGS due to surface leakage; No SHOCK when disconnecting; EASY SCALE READING in ohms, megohms, AC or DC voltage; ACCURATE in −40° to 140° F. MEASURES resistance values of insulation, windings, armatures; test wiring continuity, connections; checks for shorts, leaks, opens; tests power source voltage, AC or DC—40 models covering entire range of resistance measurement from 100 to 50,000 megohms.

ASSOCIATED RESEARCH incorporated
3754 W. Belmont Avenue — Chicago 18, Ill.

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Specified by leading manufacturers of Electrical Appliances for industry and the home. We guarantee long service and economy from this SUPER line of Cords and Cord Sets for . . .

IRONS • MIXERS • HEATERS • LAMPS
WASHERS • FANS • PORTABLE TOOLS
RANGES • RADIOS • TELEVISION SETS
VACUUM CLEANERS • REFRIGERATORS
BUSINESS MACHINES

CORNISH WIRE COMPANY
30 Park Place — New York

Gibson's Beryllium Copper Electrical Contact Springs*

for Outstanding Fatigue Resistance

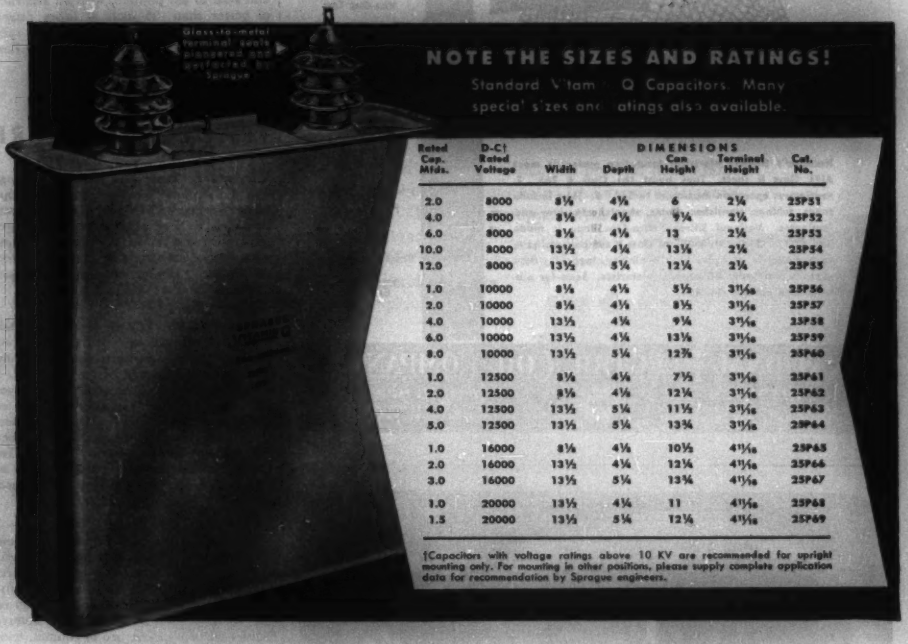
GIBSON's Beryllium Copper contact springs are suitable for unlimited service (100,000,000 cycles and more) if stresses do not exceed 40,000 PSI for the 2% beryllium springs and 35,000 PSI for the 1.7% beryllium springs. Greater stresses may be imposed when fewer operations are required. Write for literature containing electrical and mechanical properties.

*Supplied with silver, silver alloy, or Gibsiloy powder metal contacts attached.

Gibsiloy ELECTRICAL CONTACTS — Manufactured by GIBSON ELECTRIC COMPANY
8346 Frankstown Avenue, Pittsburgh 21, Pa.

SMALLER, LIGHTER, LESS EXPENSIVE

HIGH VOLTAGE D-C CAPACITORS



NOTE THE SIZES AND RATINGS!

Standard Vitamin Q Capacitors. Many special sizes and ratings also available.

Rated Cap. Mfds.	D-C† Rated Voltage	DIMENSIONS Width	Depth	Can Height	Terminal Height	Cat. No.
2.0	8000	8⅛	4⅛	6	2¼	25P51
4.0	8000	8⅛	4⅛	9¼	2¼	25P52
6.0	8000	8⅛	4⅛	13	2¼	25P53
10.0	8000	13½	4¼	13½	2¼	25P54
12.0	8000	13½	5¼	12¼	2¼	25P55
1.0	10000	8⅛	4⅛	5½	3 11/16	25P56
2.0	10000	8⅛	4⅛	8½	3 11/16	25P57
4.0	10000	13½	4¼	9¼	3 11/16	25P58
6.0	10000	13½	4¼	13⅛	3 11/16	25P59
8.0	10000	13½	5¼	12⅞	3 11/16	25P60
1.0	12500	8⅛	4⅛	7½	3 11/16	25P61
2.0	12500	8⅛	4⅛	12¼	3 11/16	25P62
4.0	12500	13½	5¼	11½	3 11/16	25P63
5.0	12500	13½	5¼	13¾	3 11/16	25P64
1.0	16000	8¼	4⅛	10½	4 11/16	25P65
2.0	16000	13½	4¼	12¼	4 11/16	25P66
3.0	16000	13½	5¼	13¾	4 11/16	25P67
1.0	20000	13½	4¼	11	4 11/16	25P68
1.5	20000	13½	5¼	12¼	4 11/16	25P69

†Capacitors with voltage ratings above 10 KV are recommended for upright mounting only. For mounting in other positions, please supply complete application data for recommendation by Sprague engineers.

USE an ordinary capacitor rated for 40°C. operation on a high-voltage d-c filtering circuit and chances are the higher temperatures encountered will necessitate a serious de-rating. In other words, you will have to buy a larger, heavier and costlier capacitor than you actually need.

Standard Sprague high-voltage capacitors impregnated with Vitamin Q, however, are rated conservatively for operation at 85°C. *They require no de-rating up to this temperature.* Special units can be supplied for continuous use up to 105°C.

These capacitors are consistently superior in their ability to maintain a high degree of capacitance-temperature stability. Power factor is outstandingly low over a wide temperature range; d-c insulation resistance is notably high; and a-c ripple voltage at audio frequencies falls well within permissible limits. Equally important, Vitamin Q impregnated capacitors have a high safety factor at all temperatures, thus assuring long life.

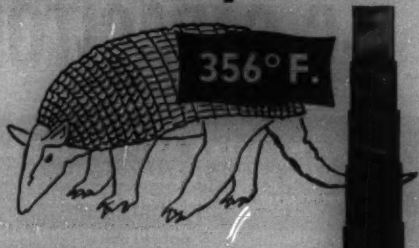
Write for Sprague Engineering Bulletin 203.

SPRAGUE **VITAMIN Q* CAPACITORS**

*Reg. U.S. Pat. Off.

SPRAGUE ELECTRIC COMPANY • NORTH ADAMS, MASS.

INSULATED to withstand continuous temperature of



Conductor: Copper wire

Conductor Insulation: Silicone Mica-Glas Tape

Ground Insulation: Silicone Mica-Glas Tape

Ground Insulation: Silicone Mica-Glas Wrapper

Outside tape: Silicone Fiberglas Tape

Finish: Silicone Varnish Used Exclusively

National's Silicone electrical insulating materials meet AIEE Class H specs. They boost the Class B 266° F. continuous operation maximum to 356° F. They include tapes, tubings, varnishes, cloths, sheets, adhesives and laminates. National Silicone Mica-Glas Tape is made just .0035" thick. All National Class H components have high dielectric strength, high flexibility, long life; they contain practically NO organic materials. Send for our Insulation Catalog No. 494.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

STODDART NM-20A
RADIO INTERFERENCE AND FIELD INTENSITY METER

- A portable unit that you can DEPEND upon to conduct scientific tests with speed, precision and economy. Ideal for field engineering and laboratory studies.
- Measures FIELD INTENSITY of any frequency and RADIO INTERFERENCE directly in microvolts.
- Operates from self-contained dry batteries or external A.C. power unit.
- May be used as a tuned voltmeter, selective or unbalanced.
- CONTINUOUS RANGE 150 kc to 25 mc.
- ONE MICROVOLT SENSITIVITY at a signal-to-noise ratio of 2 to 1.
- Complete with self-contained loop antenna.

STODDART AIRCRAFT RADIO CO.

Main office and plant: 6644 Santa Monica Blvd., Hollywood 38, Calif. Phone: Hillside 9294

8-247 General Motors Bldg., Detroit 2, Michigan. Phone: Trinity 1-9760

1346 Connecticut Ave., duPont Circle Bldg., Washington 6, D. C. Phone: Hudson 2-3181

(*Continued from page 26A*)

minute, in increments as small as 2½ feet per minute. The instrument also measures air temperatures from 30 degrees Fahrenheit to 155 degrees Fahrenheit, with an accuracy of about one-third of a degree; and static pressures directly in terms of inches of water, from zero to four negative and zero to ten positive, with an accuracy of better than .05 inch at lower range. More details concerning the air meter may be obtained from the company at 10 East 39th Street, New York 16, N. Y.

TRADE LITERATURE

Microwave Test Equipment Catalog. The Polytechnic Research and Development Company, Inc., 202 Tillary Street, Brooklyn 1, N. Y., has issued a 73-page, fully illustrated catalog containing its complete line of new precision microwave test equipment. Copies of the catalog are available upon request to the company.

Silicone Notes. Silicone greases as ball bearing lubricants are described in two publications put out by the Dow Corning Corporation. Silicone Notes number *D-5* on "Dow Corning Silicone Greases" gives the properties, performance, and uses of these heat-stable and oxidation-resistant silicone lubricants; Silicone Notes number *D-6* contains information on "How to Use DC 44 Silicone Grease in the Bearings of Electric Motors." Copies may be obtained from the company at Midland, Mich.

United States Rubber Catalog. A new 28-page catalog giving detailed design, engineering and performance data for its line of transmission belting has been published by the mechanical goods division of the United States Rubber Company. Tables on belt speeds, arc of contact, friction, horsepower correction, and service factors are included in the manual, together with hints on the proper selection of a belt and the procedure for analyzing belt drives. The catalog is available by writing to the company at Rockefeller Center, New York 20, N. Y.

"Pocket Engineer" Rules of thumb for answering three main questions concerning capacitors and for applying power-factor-improvement are now available in wallet card-size from the General Electric Company, Apparatus Department, Schenectady, N. Y. By using this card, engineers can quickly compute the answers to the questions: How many kilovars?; What power factor?; and How much voltage rise? In each case, simplified diagrams illustrate the formula that will allow quick computation to answer each problem. Copies of the card, *GEN-22*, are available upon request.

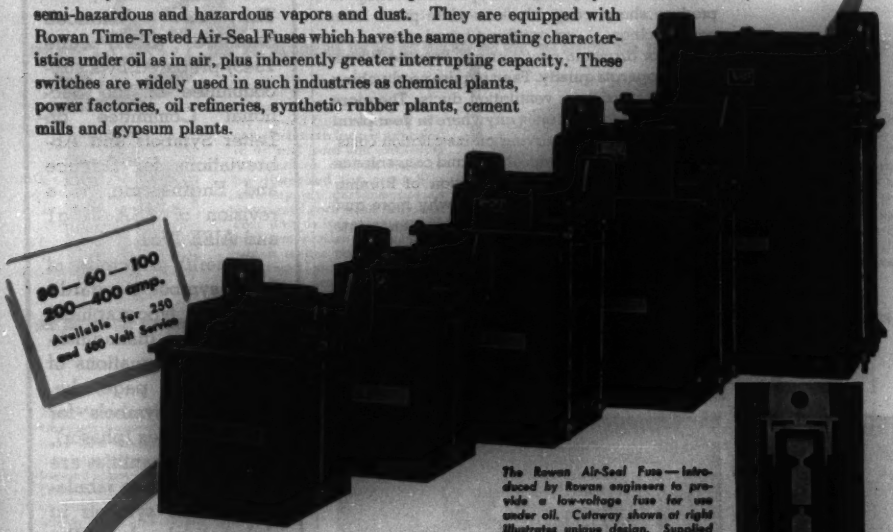
Trumbull Releases. The Trumbull Electric Manufacturing Company has issued three new brochures: "Type 'D' Enclosed

(*Continued on page 44A*)

FOR MAXIMUM SAFETY AND CONTINUITY OF SERVICE

Rowan COMPLETELY OIL IMMERSED, FUSED, SAFETY LINE DISCONNECT SWITCHES

The Rowan Type 620 Safety Line Disconnect Switches are designed to provide dependable continuity of service in locations where the atmosphere is contaminated by corrosive elements, semi-hazardous and hazardous vapors and dust. They are equipped with Rowan Time-Tested Air-Seal Fuses which have the same operating characteristics under oil as in air, plus inherently greater interrupting capacity. These switches are widely used in such industries as chemical plants, power factories, oil refineries, synthetic rubber plants, cement mills and gypsum plants.



The Rowan Air-Seal Fuse — introduced by Rowan engineers to provide a low-voltage fuse for use under oil. Cutaway shown at right illustrates unique design. Supplied in 30—60—100—200—400 amp., 250 and 600 Volt.

Standard Features of the Type 620 Disconnect Switch:

1. Completely oil immersed. 2. Equipped with Rowan Time-Tested Air-Seal Fuses. 3. Disconnect switch of the quick acting contactor type with renewable contacts. 4. Provision for locking disconnect switch in the "Off" position. 5. Safety enclosing case mechanically interlocked to prevent lowering of tank when switch is in operating position or closing of switch when tank is lowered. 6. Enclosing case is weather-resisting and dust-tight. 7. Tank handles for ease of handling.

ROWAN CONTROL

BW

you can put a Bruning Whiteprinter anywhere!

The modern design of a Bruning Whiteprinter makes it a self-contained unit. All it needs is an electric connection . . . and you are ready to produce sharp, crisp, black-on-white prints from your tracings . . . or anything typed, printed, or written or drawn in pencil or ink. Bruning Whiteprinters operate quietly. They require no plumbing connections and no ventilation ducts. Therefore they can be placed almost *anywhere* in your plant or office . . . at great saving on installation costs.

Add to this the savings of time and convenience —and the fast, uniform production of Bruning Whiteprinters. Then you can see why more and more firms are turning to BW, for better prints at lower costs.

There is a Bruning Whiteprinter model for every volume of work.

Send today for literature describing how you, too, can profit by using BW Copies. See for yourself why the BW System is the answer to your own copying needs. No obligation.

BRUNING WHITEPRINTER VOLUMATIC MODEL 93

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See Bruning Office Copying Systems Exhibit in spaces 12 and 14 at the National Business Show, Grand Central Palace, New York City, Oct. 24 through 29.

A E I

American Standard
LETTER SYMBOLS
for
ELECTRICAL QUANTITIES

This new American Standard (Z10.5—June 1949) prepared by a subcommittee of the Sectional Committee on Letter Symbols and Abbreviations for Science and Engineering, is a revision of ASA Z10g1 and AIEE 17g1.

General principles of letter symbol standardization, a typographical notation for distinguishing, in the equations of the printed page, between the symbols for scalar, complex (phasor), and vector quantities are given, as well as tabulations of the symbols in alphabetical order of the names of quantities, English letter symbols, and Greek letter symbols.

Price: $0.60; 50 per cent discount to AIEE members on single copies.

Address orders to:

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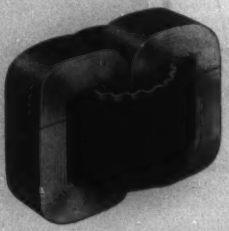
ORDER DEPARTMENT
33 West 39th Street
New York 18, N. Y.

10-49

A smaller package for a BIGGER Job!

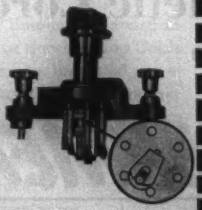
They say good things come in small packages. In the case of Moloney HiperCore Transformers, it's true! Though much smaller in size and lighter in weight, HiperCore Transformers have greater short-time overload capacity, better voltage regulation and are much more dependable for all-around sustained performance. Averaging ⅓ smaller in size and weight, HiperCore Transformers have improved characteristics, which will be reflected in your maintenance and operating records.

HiperCore Transformer cores are wound from oriented, silicon steel. Each loop is annealed in its final form and individual laminations do not have to be disturbed for assembly, assuring top performance of unstressed core steel. Annealed core loop is impregnated with high temperature plastic binder which makes possible cutting into two U-shaped pieces. Cutting burrs are neatly removed by etching.

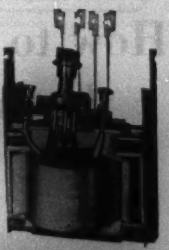


The core-and-coil unit is a center-leg type of construction, having a single coil and two core loops. Each core loop is cut into two U-shaped pieces after impregnation, and then cemented back together when the coil is in place. Steel bands around each core loop hold the two U-shaped pieces tightly together with a force of from one to three tons.

The Moloney HiperCore Tap Changer is unmatched in ruggedness and design. The plainly numbered operating handle is located *above* the hot oil level. Double-wedged contacts snap into place with a wiping action. Sturdy beryllium copper springs provide high pressure contact.



The complete core-and-coil unit for a HiperCore Transformer is the last word in compact design and superior performance. Simplicity of design plus liberal use of materials and adequate cooling ducts combine to make HiperCore Transformers cooler operating and better performing, resulting in longer life under normal operating conditions.

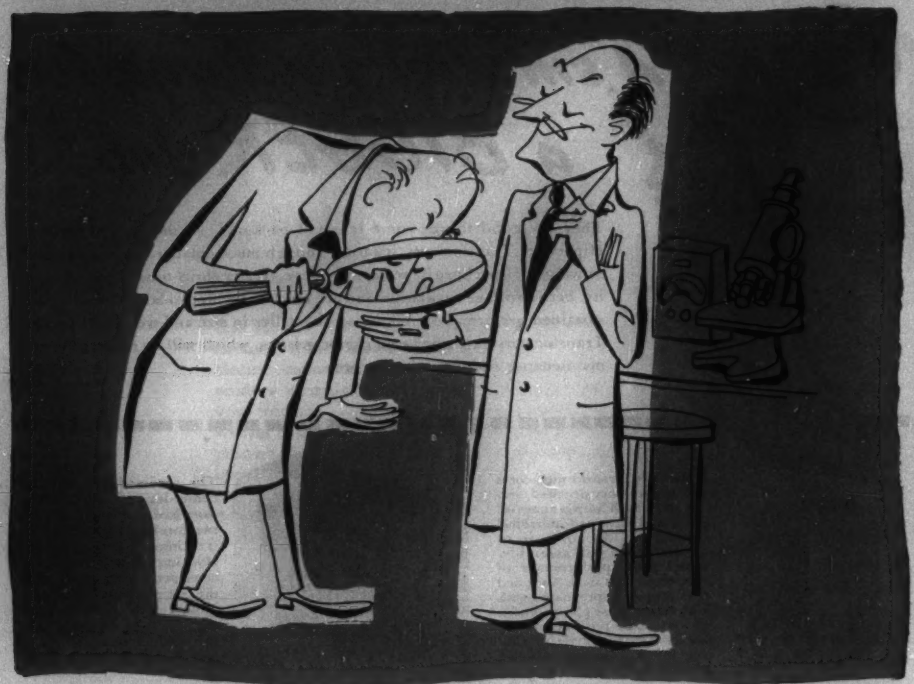


Plus FEATURES

- ✓ Lower Hottest-spot-over-oil temperature
- ✓ Longer Operating Life
- ✓ High Factor-of-Safety in Design
- ✓ Lighter Weight
- ✓ Smaller Size
- ✓ Greater Short-Time Overload Capacity
- ✓ Better Voltage Regulation
- ✓ Superior Tap Changer

Send for Bulletin H-303 describing HiperCore Transformers.

MOLONEY



How to make a Magnetic Core that's really small?

...use PERMENDUR!

Write for

BLUE SHEETS

on Allegheny Ludlum Electrical Materials

Complete, laboratory-certified data on each grade—its physical properties, electrical characteristics, uses, methods of handling, etc. Write for Blue Sheets on the materials in which you are interested.

ADDRESS DEPT. E-80.

When the conditions of service make it imperative for you to hold the size and weight of magnetic cores at an absolute minimum, that's the place to use Permendur. With this material you can push the flux density up to 20 kilogausses, and practically eliminate weight as a consideration.

Along with its suitability for cores wherever the premium is laid on compactness, Permendur is just the thing for sonar magnetostriction applications, too. We maintain proper annealing facilities for this alloy. Write for technical data on it, and let our engineers help you to cash in on its possibilities.

ALLEGHENY LUDLUM

STEEL CORPORATION

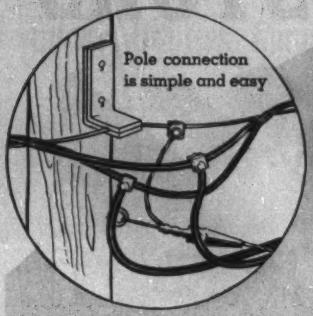
Pittsburgh, Pa.

Steel Makers to the

ELECTRICAL INDUSTRY

AL

W&G 2603



SELF-SUPPORTING RoPrene

SECONDARY and SERVICE DROP CABLE

Service drop connection to house simplified with fittings and hardware commercially available.

Photo courtesy Forge Mfg. Co., Inc.

FOR ECONOMY IN AERIAL SERVICE

As a new development of time-proven construction, RoPrene Secondary or Service Drop Cable consists of RoPrene (Neoprene) insulated power conductors, spiralled around a "straight-away" neutral conductor for mechanical support. Here is simplicity in construction, economy of installation, longer life under all weather conditions . . . plus the neater appearance of a single cable assembly compared to open wires.

These advantages can be yours:

- **Lower Cost**
- **Ease and Economy of Installation**
- **No Mechanical Stress on Power Conductors**
- **No Coverings to Rot and Festoon**
- **High Weather Resistance**
- **Reduced Maintenance**
- **Neat, Compact Appearance**
- **Versatility**

Write today for Bulletin RS-4. See for yourself why, more and more, RoPrene Secondary and Service Drop Cable is becoming the accepted cable for overhead services. Available in a wide range of types and sizes.

FROM BAR TO FINISHED WIRE

ROME CABLE CORPORATION

ROME · NEW YORK

OHMITE RESISTORS

Write on Company Letterhead for Catalog 40

Standard Types and Sizes To Meet Every Need

The extensive range of Ohmite types and sizes makes possible an almost endless variety of standard Ohmite resistors to meet each individual need. Ohmite offers resistors in more than 60 core sizes, in a wide range of wattage and resistance values. There are also 18 types of resistor terminals available. Included in the Ohmite line are fixed, adjustable, tapped, non-inductive, and precision units.

These rugged resistors have proved their worth under the toughest operating conditions. Specially developed vitreous enamel holds the winding rigidly in place and protects it from mechanical damage, shock, vibration, cold, heat, fumes, and humidity—providing years of unfailing performance. Ohmite engineers will be pleased to help you in selecting the right resistors for your job.

OHMITE MANUFACTURING COMPANY
4902 Flournoy St., Chicago 44, Ill.

Be Right with . . .

OHMITE
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RHEOSTATS • RESISTORS • TAP SWITCHES

Industry's First Choice

Kentucky Utilities Company, Inc.
chooses
Steel Towers
for 138 K. V. Single Circuit Line

● When Kentucky Utilities Company, Inc., selected American Bridge light steel towers for its 138 K.V. single circuit line, it found that these towers made possible more severe design conditions because they had sufficient strength to carry longitudinal, transverse and vertical loads. Also, Kentucky Utilities found that foundation erection was quicker and cheaper because the circular steel grillages of the towers were designed to permit machine boring of anchors. Conductors and ground wires were carried in the most economical spans and the exact arrangement desired. And, like most things made of steel, these towers have the stamina to provide extra years of service.

To help you take advantage of the outstanding superiority of steel for structures of this type, American Bridge Company makes available its experience and facilities for designing, fabricating and erecting. Why not submit any questions you might have to our nearest Contracting Office.

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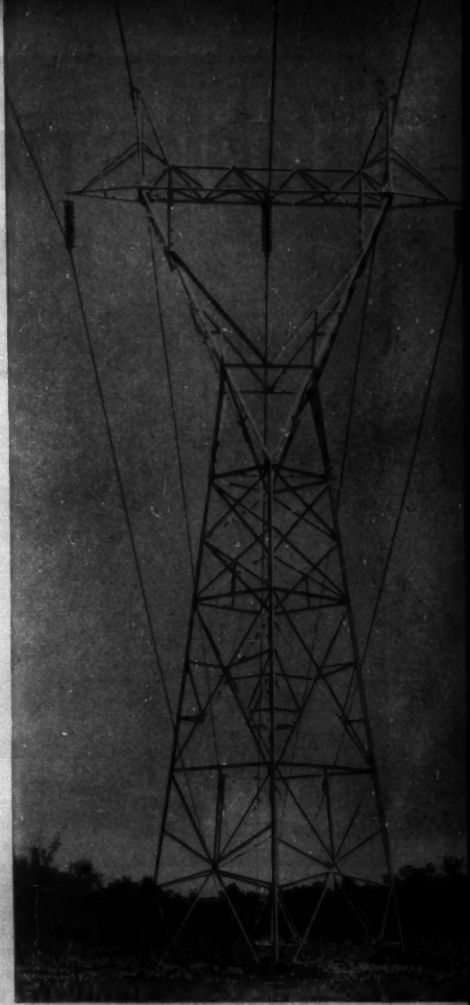


Dix Dam—Green River line. Single circuit 138 K.V. rotated towers with three 556,500 C.M. conductors and two 7/16" ground wires. Length=140 miles.

USS **AMERICAN BRIDGE**

UNITED STATES STEEL

Cables run COOLER...
in TRANSITE DUCTS

. . . reducing copper losses

. . . increasing current capacity

. . . prolonging insulation life

HERE'S HOW to reduce copper losses . . . increase current carrying capacity . . . and prolong insulation life—run your cables in Transite* Ducts.

Current carrying capacities can be increased in a typical duct bank as much as 5%, or I^2R losses can be reduced 11%, for cables located in Transite as compared with other ducts used for power circuits.

And, Transite Ducts assure permanent duct banks because Transite is incombustible; is immune to rust and rot; is unaffected by electrolysis; will not slag under action of an arc, and will retain its high original strength.

An unusually smooth bore assures no injury to cable sheath, either in natural movement under load, or when pulling-in cables. Long, lightweight lengths can be quickly and economically installed. In addition, a full line of fittings simplifies even the most complicated of installations.

For full information on Transite Ducts, write for Data Book DS-410. Johns-Manville, Box 290, New York 16, N. Y.

JM

*Reg. U. S. Pat. Off.

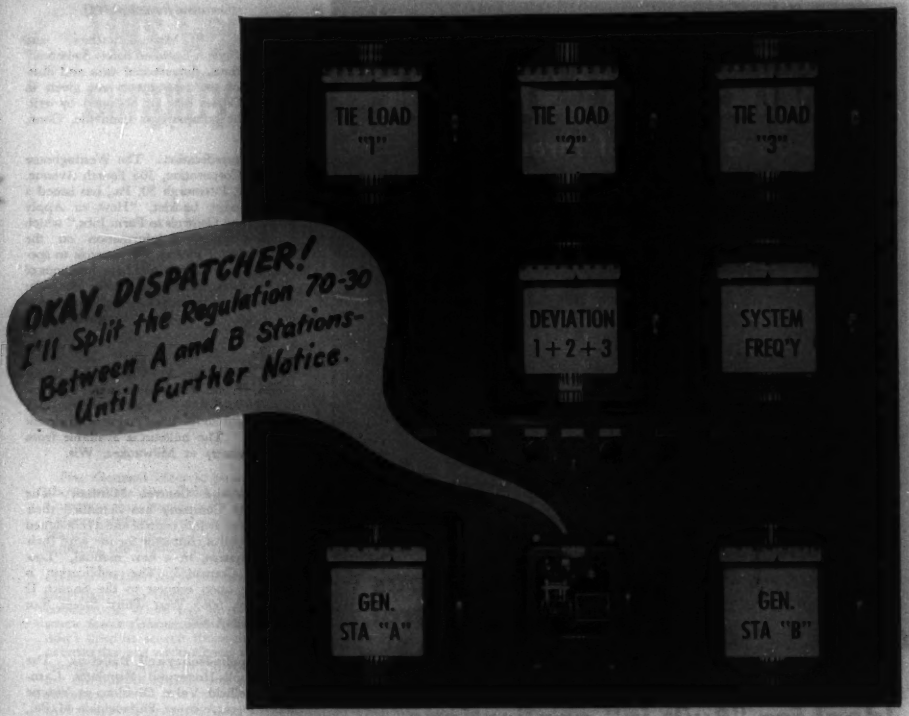
How Transite Ducts Increase current carrying capacities

Type cable 3 cdr. 500 MCM Compack Sector, 15 KV (6th Edition AEIC Spec.)
No. of cables—3 (all loaded in one bank)
Daily Load Factor—75%
Earth Temp. ambient—20 C

	Transite	Other
Total Therm. Res. to Dielectric Loss (C watts/ft.)	5.66	6.17
Total Therm. Res. to Copper Loss (C watts/ft.)	4.44	4.95
Temp. Rise from Dielectric Loss (C)	1.9	2.1
Allowable Rise for Copper Loss (C)	59.1	58.9
Allowable Watts per ft. cable	4.44	3.96
Allowable Current—(Amps. per cdr.)	386.	365.
Allowable Current—(Relative %)	105.6	100.

Johns-Manville *Transite Ducts* "KORDUCT"—for encasement in concrete

"CONDUIT"—for use exposed and underground without encasement



The practice of dividing load-regulation between several generating stations is actually over five years old, on some systems and in our experience with the instruments. For it was in 1944, in a southern load-dispatcher's office, that the above panel was put to work. The office faced the problem of preventing unwarranted deviations from the scheduled net interchange across three tie lines, and the panel of instruments was installed to help prevent such deviations, while dividing the required load regulation between two generating stations.

In addition to the L&N Load-Frequency Controller, which is doing the "talking" in the above illustration, the panel has the following instruments: At top, three Tie Line Load Recorders, which show actual power flow on the lines; a Recorder for net deviation from schedule on the three ties; a system Frequency Recorder; and two Recorders, for generation at the two stations.

Operation can be summarized as follows: Suppose that the approximate generation on the two regulating stations is nominally 100,000 Kw, exclusive of the regulating burden which is plus or minus that figure. Suppose also that efficiency dictates about 70,000 for one station and 30,000 for the other. The great value of the panel then is this: By merely setting dials in the instruments, the system operator can assign the nominal load 70–30, while assigning the plus or minus regulating burden 2 to 1, or in any other ratio he sees fit. He can thus maintain the scheduled interchange while dividing the regulation.

A similar control set-up, with appropriate additional instruments, could of course handle any number of regulating stations. For a general description of the instrumentation, and of other types of regulation it can provide, ask for our Technical Publication N-56-161-(1). Address Leeds & Northrup Co., 4962 Stenton Ave., Philadelphia 44, Pa.

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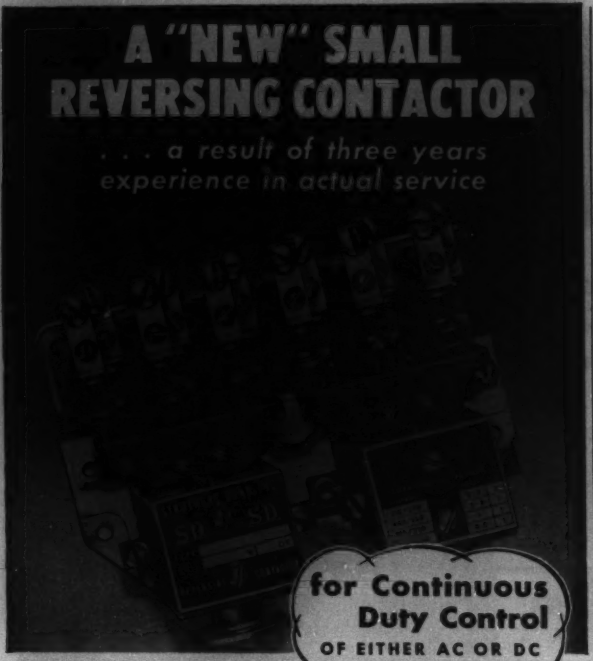
A "NEW" SMALL REVERSING CONTACTOR

. . . a result of three years experience in actual service



for Continuous Duty Control OF EITHER AC OR DC EQUIPMENT

Ideal for "Built-in" applications . . . Completely serviceable from the front

THE FIRST small reversing contactor, introduced by Struthers-Dunn over 3 years ago, represented a big improvement over existing methods of controlling hoists, door operators and similar equipment. The design of this new contactor, Type 175KXX is based on broad experience in applying the original unit and incorporates still further advantages including greater ruggedness and the ability to withstand continuous service. Ratings are as follows:

AC single phase: 1 hp. 115 or 230 volts
AC polyphase: 2 hp. 110 or 220 volts
1 hp. 440 or 550 volts
Direct current: 1 hp. 115 or 230 volts

Two 3-pole solenoids, for forward and reverse operation, are mounted on a common frame and mechanically interlocked to prevent simultaneous closure. Contacts are completely insulated with melamine. Open arc chutes allow rapid cooling and escape of ionized gases.

Auxiliary contacts can be added for electric lock-up or interlock. All fixed contacts are interchangeable as are the moving contacts and corresponding parts on each solenoid. All parts are easily replaceable from the front.

Write for Data Bulletin 7100.

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Struthers-Dunn, Inc., 150 N. 13th St., Philadelphia 7, Pa.

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(*Continued from page 34A*)

Switches;" "TT Manual Starters;" and "Type A Style A Enclosed Safety Switches." Specifications, dimensional data and illustrations of the instruments are given in detail. Copies may be obtained by writing to the company at Plainville, Conn.

Farm Electrification. The Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa., has issued a new 15-page booklet, "How to Apply Motors and Controls to Farm Jobs," which contains practical information on the application of motors and controls to specific farm operations; the basic functions of the portable motor and motor controls; and the advantages of electrical farm power. For a copy of booklet *4155*, write to the company.

Oil Circuit Breaker Bulletin. Allis-Chalmers has released a new bulletin, *71B6129D*, which describes types DZ-60,100, and 200B Allis-Chalmers oil circuit breakers. The bulletin is available from Allis-Chalmers at Milwaukee, Wis.

Low Voltage Control Manual. The Square D Company has described their new selector switch control and a redesigned master control contactor for use with their 24-volt system, in a new manual, "Low Voltage Control." The publication is available upon request to the Square D Company, 6065 West Third Street, Los Angeles 36, Calif.

Minneapolis-Honeywell Bulletins. The Minneapolis-Honeywell Regulator Company, Belfield Valve Division, at Wayne and Roberts Avenues, Philadelphia 44, Pa., has issued three new pamphlets. Bulletin number *48-1* describes liquid level controllers; bulletin *254-1* describes the operation and construction of the Schaefer By-Pass for traps, valves, and other pressure units, as well as the Union Bonnet type for general marine service; and bulletin number *350-1* offers dimensions and operating data on the Belfield "On-Off" air-operated diaphragm control valve. Copies will be sent upon request to the company.

Rectifier News. The "Rectifier News" is a four-page periodical published bimonthly by the International Rectifier Corporation, devoted to current information on selenium dry-disc rectifiers. Anyone wishing to receive the publication regularly should contact Mr. Philip Diamond, Application Engineer, International Rectifier Corporation, 6809 South Victoria Avenue, Los Angeles 43, Calif.

Cable Data Book. The Aluminum Division of the Permanente Products Company, 1924 Broadway, Oakland 12, Calif., has issued a data book on Kaiser aluminum cable, steel reinforced, and all aluminum cable, which presents detailed information on the physical and electrical properties of Kaiser aluminum cable, as well as the electrical conductor standards on which the tables are based. Copies of the booklet will be sent upon request to the company.

This General Electric power connector can simplify your inventory by 63% to 83%

G-2 Block Terminal Connector—Class A-2

Five General Electric power connectors of the type shown above will handle *all* the 22 conductor sizes listed in the table*. Compare this feature with other brands that usually *require a different connector for each conductor size.* You'll immediately realize how much G-E connectors can cut your stock costs by reducing the number of connectors required.

Here are other ways you can SAVE by using G-E connectors.

SAVE TIME—No more stock room safaris hunting for odd-size connectors. When you stock General Electric connectors, you stock fewer connectors. Also, you save time in ordering—you don't have to search through bulky catalogs looking for connectors that are seldom used and are a nuisance to order, besides taking up valuable stock space. G-E connectors are easy to order for the simple reason that you don't have to order so many varieties.

SAVE SPACE—Less stock room space required when you use G-E connectors because fewer connectors are needed to take care of the same range of conductor sizes that you're using now.

SAVE MONEY—When you use G-E connectors you reduce stock storage costs, and you save valuable time in ordering.

CHECK THESE ADDITIONAL FEATURES OF GENERAL ELECTRIC CONNECTORS

SILVER CONTACT SURFACES are a *standard* feature on *all* G-E connectors for use with copper conductors—at no extra cost. This eliminates oxidation problems, assures lower contact losses and longer life.

SERRATED CONTACT SURFACES give extremely high pull-out strength and a permanent, high-conductivity joint that will resist vibration and give positive pressure on the cable at all times.

NON-CORRODIBLE HARDWARE is of high-strength bronze alloy that gives tight and trouble-free service. G-E connectors will not twist, distort, or season crack.

INTERLOCKING SIDES confine the strands of the cable within the conductor enclosure, thus obtaining full advantage of the cable's current-carrying capacity.

Place an order today with your G-E sales representative and start realizing the many benefits to be gained by using this new line of General Electric connectors. Also, write for a copy of bulletin GEC-400 that contains 38 pages of valuable information on these new connectors, and see for yourself how easy they are to order. Write to *Apparatus Department, Section H856-51, General Electric Company, Schenectady 5, New York.*

*General Electric connectors come in a wide range of sizes and types—straight, tee, block, angle, parallel, expansion, ground, and many others. See bulletin GEC-400 for the complete line.

Conductor size	General Electric Catalog No.	Connector Mfg. A	Connector Mfg. B	Connector Mfg. C	Connector Mfg. D
1/0	6151174-9 One G-E connector replaces 6, stock is reduced 83⅓%	√	√	√	√
2/0		√	√	√	√
3/0		√	√	√	√
4/0		√	√	√	√
250		√	√	√	√
300		√	√	√	√
350	6151174-59	√	√	√	√
400		√	None	√	None
500		√	√	√	√
600		None	None	√	√
½ IPS		√	None	√	√
700	6151174-88	None	None	√	None
750		None	None	√	√
800		None	None	√	√
1000		None	None	√	√
3/4 IPS		√	√	√	√
1250	6151174-118 One G-E connector replaces 3, stock is reduced 66⅔%	None	None	√	√
1500		None	None	√	√
1 IPS		None	None	√	√
1750	61151174-148	None	None	√	√
2000		None	None	√	√
1¼ IPS		None	None	None	√
Only 5 G-E connectors for ALL 22 conductor sizes		11 connectors for 11 cond. sizes. No connectors available for 11 conductor sizes	9 connectors for 9 cond. sizes. No connectors available for 11 conductor sizes	21 different connectors for 21 cond. sizes	20 different connectors for 20 cond. sizes

√ Indicates a different connector.

GENERAL ELECTRIC

Use

FASCO

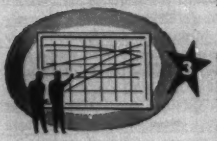
Five ★ Point

CUSTOM ENGINEERING SERVICE

Shaded Pole
1/500 to 1/8 H.P.

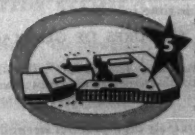
DIRECT FACTORY ENGINEERING SERVICE—Extensive motor technology, accumulated through years of Fractional H.P. Motor engineering and manufacture brought to your own plant by our experienced, factory-trained engineers.

RIGHT PRICE—To allow widest margin in pricing for competitive selling . . . FASCO "Custom Engineering Service" utilizes the economy of a basically *standard* production line motor . . . *custom engineers* it to fit *your* special needs.



EFFICIENT PERFORMANCE—So important to the success of *your* product . . . proved by FASCO'S continuing success and growth . . . attained by building the maximum in quiet, economical, trouble-free operation into motors for many thousands of products that have served users with full satisfaction.

FASCO QUALITY—Adds an extra measure of value to your product. Every step in the manufacture of FASCO Motors . . . from raw stock to final test . . . is under rigid uniform control of the most precise instruments and methods.



DEPENDABLE MANUFACTURER—Not a giant plant, nor a small one. But a medium-size (250,000 sq. ft.—1,000 employees) well-established reputable manufacturer you can depend on for *delivery* as well as for quality of product.

WRITE on your company letterhead for complete information on FASCO "Custom Engineering Service," and catalog.

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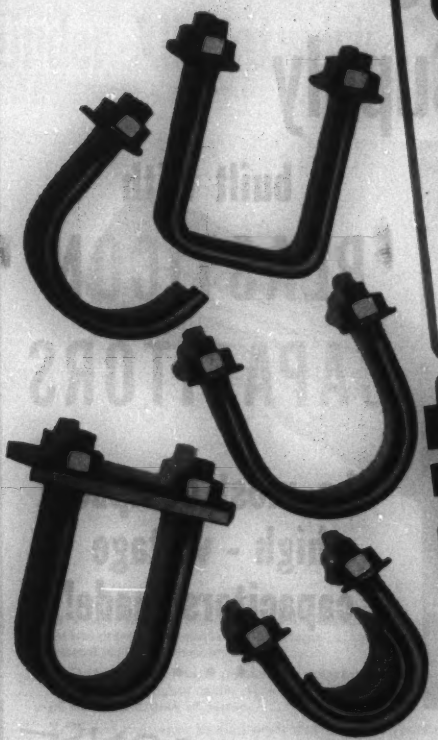
MOTORS and BLOWERS

OVER 78 WAYS TO MAKE SURE CONDUITS STAY PUT!



O.Z. has 'em ...IN STOCK

When you need U-BOLTS for that conduit or cable clamping job, try O-Z.

WHY?

BECAUSE the O-Z line is *in stock*, ready for immediate shipment.

BECAUSE the stock O-Z line has over 78 sizes and types for conduits from ½" to 6". As just one example, you can get *three* bolt diameters, for 1", 1¼" or 1½" conduit. You can get O-Z U-BOLTS, from stock of Everdur, steel cadmium plated or steel hot-dip galvanized. They come with nuts and flat washers, with or without saddles. They provide for clamping to a ⅜" thick plate using nuts and washers on each leg.

BECAUSE O. Z. will manufacture U-BOLTS of any size or material to meet your specifications.

There are thousands of O-Z products designed to help you put power where you want it, and your O-Z Distributor is the man to see about them. Send for illustrated catalog.

and Remember!
THEY'RE O.K. IF THEY'RE O.Z.

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CONDUIT FITTINGS
CABLE TERMINATORS
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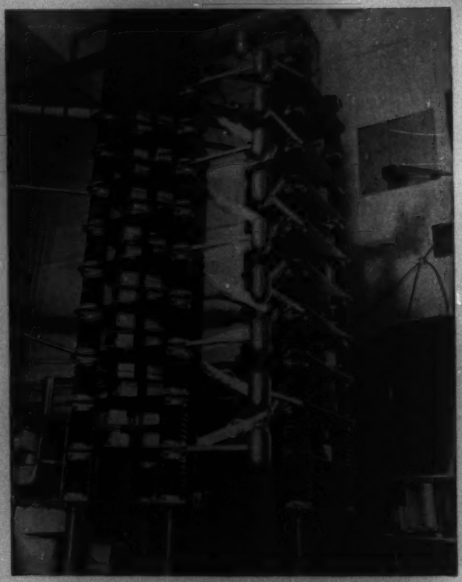
3060

600,000 Volt Power Supply —



An 8 stage capacitor-rectifier multiplier. This unit is used in the "Racetrack" Synchrotron of the University of Michigan.

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the most compact, high - voltage capacitors made!

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Standard and Special PLASTICONS—

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ANW
(Anaconda Net Work)

Time-tested since 1932 under all service conditions, subsequent improvements provide additional security in this long-famous network cable.

● Tough, easily handled, Type ANW-insulated, neoprene-jacketed cable incorporates six important advantages . . . important to you for underground duct installation:

1. Better heat and flame resistance—protected by the same neoprene jacket as Anaconda mining cables which must and do meet the severe flame test of the U. S. Bureau of Mines.

2. Higher resistance to duct acids and alkalies—years of experience with Type ANW insulation with only a braid covering showed it to be highly resistant to oils, acids and alkalies encountered in soil and sewage waters. NOW it has the additional protection of the neoprene jacket which itself has shown by test and experience, excellent resistance to these agents of destruction.

3. Higher operating temperature—now 75 C copper temperature, continuous duty.

4. Superior aging—Type ANW insulation has demonstrated year after year . . . and now even better . . . long-aging characteristics under severe oxygen bomb and air bomb tests.

5. Low moisture absorption—Type ANW insulation has always had low moisture absorption . . . far less than is detrimental to safe operation.

6. More easily handled — passes 180 degree cold-bend test at 0° C without damage to jacket. Cable is lighter, easier to pull. No lead to fuse, insulation and jacket do not support combustion.

49442

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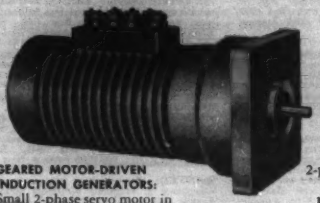
Nos. 601 and 602
Preferred Standards for Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generators (Larger Than 10,000-Kw Rated Capacity)
and
Standard Specification Data for Generators for Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generators (Larger Than 10,000-Kw Rated Capacity). May 1949. Price: $0.60.

There is a 50 per cent discount to AIEE members on single copies. Orders for the above should be sent to the AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

*10-49

extreme precision, instant response in remote indication and control

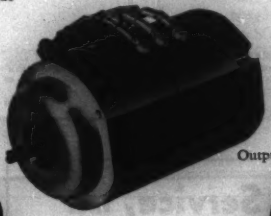


GEARED MOTOR-DRIVEN INDUCTION GENERATORS: Small 2-phase servo motor in combination with a compact gear-reducer and a low residual induction generator. Motor has high torque/inertia ratio and develops maximum torque at stall. Gear-reducer permits a maximum torque output of 25 oz. in. and is available in ratios from 5:1 to 75,000:1.

INDUCTION MOTORS: miniature 2-phase motors of the squirrel cage type. Designed specifically to provide fast response to applied control signals and maximum torque at zero r.p.m. Unit shown weighs 6.1 oz. and has stalled torque of 2.5 oz. in.

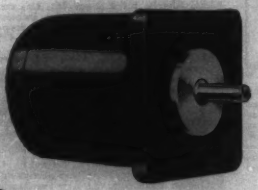
CIRCUTROL UNITS: rotary electromagnetic devices for use as control components in electronic circuits and related equipment. Single and polyphase rotor and stator windings are available in several frame sizes. Deviation from sine accuracy of resolver shown is ±0.3% of maximum output.

SYNCHRONOUS MOTORS: for instrumentation and other applications where variable loads must be kept in exact synchronism with a constant or variable frequency source. Synchronous power output up to 1/100 H.P.



SYNCHRONOUS DIFFERENTIAL UNITS: electro-mechanical error detectors with mechanical output for use in position or speed control servo systems. These torque-producing half-speed synchroscopes are composed of two variable frequency synchronous motors and a smoothly operating system of differential gearing.

Output: Speed $= \frac{N_1 - N_2}{2}$; Torque up to 1.0 oz. in.



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Positions Wanted

ELECTRICAL ENGINEER—B.S.E.E. January 1949, age 24, single, ex-naval officer with 1 year experience as engineering officer afloat. 6 months experience as sales engineer with electrical manufacturer. Desires position overseas or in western U.S.A. Address: Box 832, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

GRADUATE ELECTRICAL ENGINEER, age 35, test experience on large and small generators, motors, controls, and transformers. Sales experience with National Electrical Apparatus manufacturer. Now manager of company dealing in sales, service, and repair of electrical apparatus, desires similar position in South America on profit sharing plan. Also would consider power plant or distribution work. Address: Box 833, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER, 25, B.E.E. 1949, one year jig and instrument experience. Will consider any related position. Address: Box 834, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELEC. ENG., B.S.E.E. 1938, E.E. 1944, Missouri School of Mines, 33, single, registered, Member A.I.E.E., Fel. A.A.A.S., 11 years executive management of power utilities and construction supervisor-inspector steam-electric central stations. Desire same with present minimum salary $7200 in U.S.A. Available world wide. Address Box 835, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER, graduated from University of Minnesota, power option, desires training position, age 21, single. Address: Box 836, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER, B.S.E.E., R.I. State College, June '49. Desires position or training in electronics or other communication work. Radio operator in A.A.F. 1½ years. First class phone license. Age 24, married. Location immaterial. Address: Box 837, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

SALES AND SERVICE—Registered engineer, diversified industrial and application experience: electrical, mechanical, desires position to serve industry in Connecticut. Instruments, process equipment, materials, components. Mature, practical, good business sense. Address: Box 838, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER—June graduate, married, 29 yrs. old. B.S. in electrical engineering (power). 4 yrs. Army Communications Officer. Ambitious, capable, excellent military and scholastic record. Desires position which will lead to engineering sales work. Location anywhere in or out of U.S. Address: Box 839, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WASHINGTON REPRESENTATIVE available—12 years experience in sales and service with Gov't. departments. James F. Hardy, Barr Building, Washington 6, D. C.

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ELECTRONICS ENGINEER—Well known, 40 year-old manufacturer of electrical and electronic instruments wants research engineer experienced in design of radio electronic apparatus at high radio frequencies, for the development of military and civilian test equipment. Address: Box 697, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

PROFESSOR OF COMMUNICATIONS ENGINEERING needed for Fall 1949 by Southeastern University. Will be in charge of graduate work and research activities. $6000 for nine months with extra income for summer teaching. Must have Ph.D. degree. Address: Box 735, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

GRADUATE ELECTRICAL ENGINEER, 10–15 years experience in public utility work with about 5 years in rate and cost analysis. Location New England. Please submit summary of personal data, education and experience record. Address: Box 840, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED RELAY ENGINEER—Minimum of one and one-half years' experience in field work, checking, setting and testing protective relays and associated equipment and control circuits, to work for a large eastern public utility company on protective relay application, relay specifications, short circuit calculations, relay settings, schematic diagrams, and similar work. Location Western Pennsylvania. Qualifications, experience record, and picture should be submitted with letter of application. Address: Box 841, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED: Electrical or electronic engineers with experience in magnetic recording techniques and or systems, preferably in the computer field. Address Box 842, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the first of the month preceading issue; i.e., September first for October issue.

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Apply by letter addressed to the key number and mail to the New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

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ELEC ENGR, B.S.E.E., Naval Academy grad; 27, married; available for travel or foreign residence; 3 yrs exper ship engg, 2 yrs elec (civilian). Desires sales, installation or des. E-464.

RADIO BROADCAST ENGR, B.S.E.E., 1939; last pos Chief Engr constructing large station with complex directional antenna; exper in AM, FM, TV, 50 kilowatt transmitters, network; military radar exper. E-465.

ELEC ENGR, rec grad, married, desires pos with future. Willing to relocate. E-466.

ELEC ENGR, B.S.E.E., 1949; 22, single; desires pos pwr distr, planning, application, field work. Prefers midwest or western U.S. Will consider foreign employment. E-467-121E.

ELEC ENGR, B.E.E.; age 28; 3 yrs comm, 1 yr servo application. Prefers servo pos in growing concern. E-468.

ELEC ENGR, age 28; 1 yr util, desires pos with pwr eqpt manufacturer in designing and devpmt eqpt. Location anywhere. E-469.

GRAD ELEC ENGR, 38, married; 15 yrs exper hydropower, indus elec engg in America and Europe; also research, bus admin. Desires promising respons pos with consulting engrs, util, large mining or indus enterprise or research inst. Any location though Northwest, Canada, Alaska pref. Reasonable traveling. E-470.

ELEC ENGR, 1922 grad; age 49; indus and consulting exper in pwr and mech eqpt application, sales and service in the steel, petroleum, natural gas and carbon black industries; location immaterial; registered in Texas. E-471.

ELEC ENGR, B.S.E.E.; 42, married; 3 yrs indus control; 4 yrs commanding officer U. S. Navy shipbuilding and ship repair; 9 yrs elec util opern, constr, spec work. Will locate anywhere in U. S. E-472.

REC GRAD ELEC ENGR, B.E.E., pwr and indus electronics option; 24, single; was foreman in Army Engineers; energetic worker. Desires pos in mfg. Location immaterial. E-473.

REC GRAD ELEC ENGR, Lehigh Univ; age 25; desires pos with company that has training program. Willing to travel anywhere. E-474.

REC GRAD ELEC ENGR, B.E.E. Cornell Univ, administrative pwr option; 22, single; capable, willing to work hard given the opportunity; member Tau Beta Pi, Eta Kappa Nu; salary, location unimportant. E-475.

ELEC ENGR, B.E.E., June 1949; age 22; ambitious, adaptable; willing to travel; will relocate; desires pos in electronics or machinery. E-476.

ELECTRONIC ENGR, M.S.E.E.; age 29; 2 yrs radar exper; 2½ yrs commercial radio devpmt, transmitters, monitoring circuits; 1 yr rec grad work specializing in servomechanisms. Desires pos in research or devpmt. East or midwest preferred. E-477.

ELEC ENGR, 20 yrs exper with util on supervn, des and constr of pwr lines including 132 kv. Best references. Registered. East preferred. E-478.

ELEC ENGR, B.E.E.; age 26; 4½ yrs civilian and military skilled radio and radar technician. Desires electronic pos, lab. asst, des and devpmt or prod. Salary secondary. East preferred. E-479.

ELEC ENGR, B.E.E., 1949; 25, married; desires devpmt work in servos or work with elec strains, gages, some exper with latter. Top 5% of class. Location immaterial. E-480.

GRAD ELEC ENGR; 25, married; 2 yrs exper des drafting electro-mech circuits; interested indus elec tronics and public util work. Prefers New York Metropolitan area. E-481.

JR ELECTRONIC ENGR, B.Aero.E., 1948; B.B.A. by 1950; 1½ yrs Navy and commercial electronic technician experience; 1½ yrs mechanical devpmt of stabilized aircraft radar projects. Interested servo and instrument work. New York Metropolitan area preferred. E-482.

Positions Available

ENGINEERS. (a) Electrical Engineer, 30–40, preferably with Ph.D. degree in electronics, with experience in communications for research work on digital-type electronic computers. Salary, $7500 a year. (b) Electrical Engineer, 30–40, with M.S. degree, for work as above. Salary, to $6000 a year. (c) Junior Electronic Engineer, 28–35, with two years experience. Salary, to $4500 a year. Location, Connecticut. Y-2681.

ELECTRICAL ENGINEER, 25–32, electrical graduate, with electrical and mechanical precision products experience, to assist in coordination of changes in specifications, design, etc., between engineering, production, inspection, sales and service. Location, Connecticut. Y-2722.

ENGINEERS. (a) Electrical design and development engineer for home radio and television receivers. Must have at least ten years previous experience on design and development work in radio or television. (b) Junior Engineers for design and development of radio or television. Salaries open. Location, Pennsylvania. Y-2739.

SENIOR ENGINEER, to 35, with Ph.D. in nucleas physics, and experience on nuclear instrumentation, to design special Geiger-Mueller and Proportional Counters. Salary, $4200–$5400 a year. Location Massachusetts. Y-2748.

SALES ENGINEER TRAINEE, mechanical or electrical graduate, under 35; two years' experience with elevator installations. Train for service selling position. Salary open. Location, Chicago, Illinois. R-5883.

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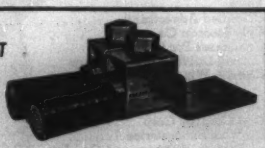

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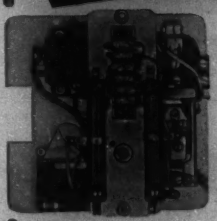

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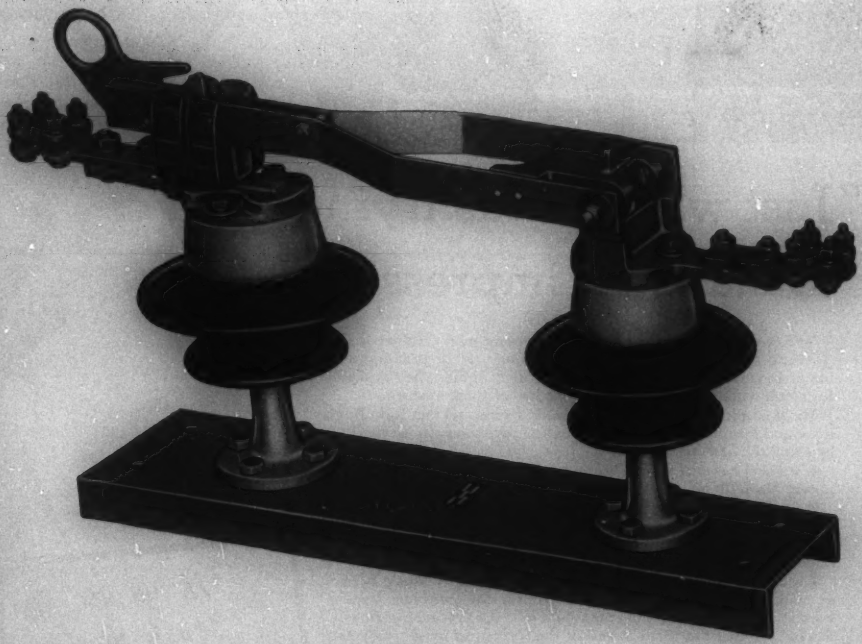

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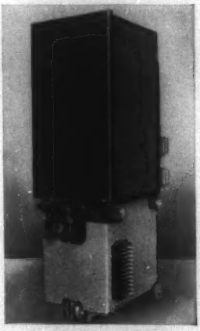

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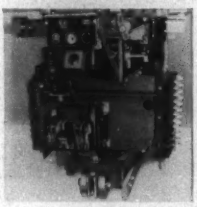

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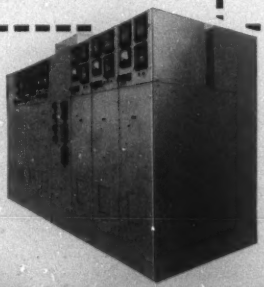

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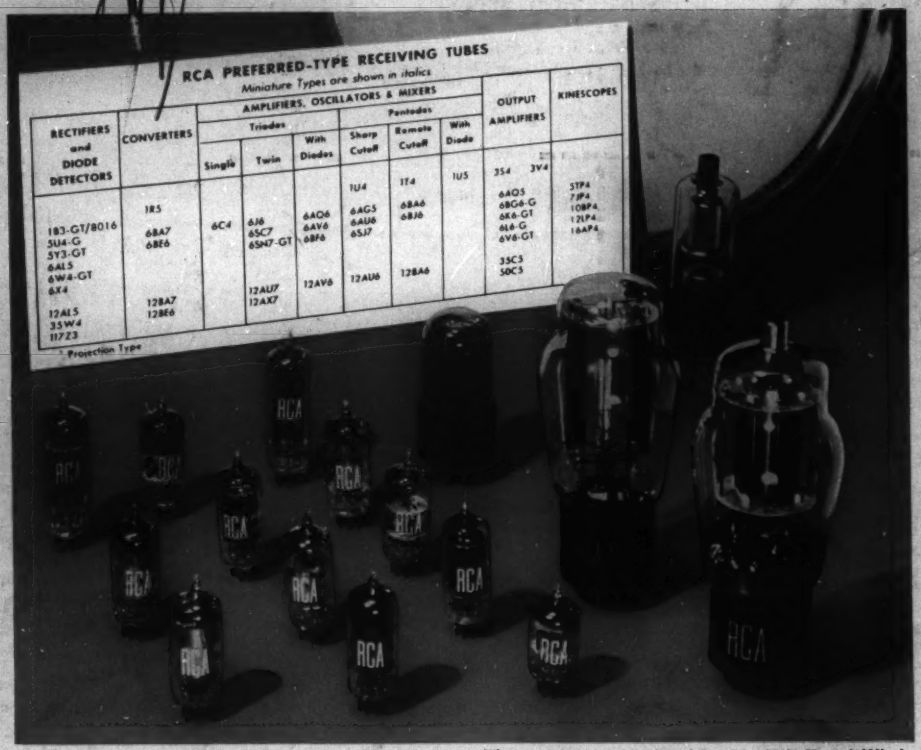

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